VISION AS IT RELATES TO READING AT THE COLLEGE LEVEL

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CHAPTER I

INTRODUCTION

Need for the Study

The demands upon the reading skills of college students are steadily increasing. It is now estimated that man's knowledge doubles every seven years. And this knowledge is not simply recorded, it is considered and reconsidered in hundreds of different relationships.

The college textbook is only the beginning for the student today. Far from containing the accumulated knowledge on any subject, a text is likely to be a reference source to studies in depth despite its summary and commentary. Pauk points out that:

> Today's students are confronted with a reading task which differs decidedly from that which students faced only a decade ago . . . . The student must 'run' to stay abreast fast-developing fields and areas by riffling through stacks of journals, magazines, newspapers, theses, bulletins, and microfilms which contain the findings of research from various parts of the world.[1]

It is not unusual to hear a college freshman state that the volume of reading assignments is overwhelming. Consider the fate of a student who desires to participate in a reading improvement course but

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[1]Walter J. Pauk, "Basic Skills Needed in College Reading," in J. Allen Figurel (ed.), Reading for Effective Living, IRA Conference Proceedings, Vol. 3 (New York: Scholastic Magazines, 1958), p. 44.

drops out because he does not dare take the time from his tightly meshed schedule.

Nor does the problem end with the beginning college students. Spache and Berg[2] estimate the average businessman spends fifteen to twenty hours a week reading technical reports, trade journals, and correspondence relating to business. This is only preparation for his job, yet it equals one-half the work-week of a wage earner.

Unable to maintain adequate contact with their field by reading, many professional men return to summer workshops or to graduate study. Bingham[3] stated that recent graduates in Electrical Engineering often return to the University of Colorado for advanced study, but must re-enter undergraduate courses to grasp newly-developed concepts.

Conscious of these demands upon students' reading skills, colleges began offering reading improvement courses. Shaw reports only a few programs offered prior to 1950, but by 1960 there were four hundred courses in the colleges of the nation.[4] Despite diversity of method and goals, the programs developed to serve millions of students.

A constant demand for careful consideration of aims and methods accompanied the development of programs. Recently Shaw pointed out that

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[2]George D. Spache and Paul C. Berg, Better Reading for Business (New York: Thomas Y. Crowell Co., 1958), p. 1.

[3]Lloyd A. Bingham, Professor of Electrical Engineering, University of Colorado, in a personal interview, December, 1964.

[4]Philip B. Shaw, "College Reading Improvement Programs of the Future," in J. Allen Figurel (ed.), Changing Concepts of Reading Instruction, IRA Conference Proceedings, Vol. 6 (New York: Scholastic Magazines, 1961), p. 48.

"the multifarious differences among the nation's college reading programs are well known," but went on to state that the trend of future college reading improvement programs was away from differences toward eclecticism.[5] Shaw also indicated the need for "recognition and acceptance of the principle of a student's sequential reading development from the elementary school through college," and for integration of instruction in reading into the regular college offering.[6]

This emphasis upon mass instruction is somewhat in contrast to a concomitant development of the application of clinical techniques to the problems of reading. Raygor notes that only recently has there been a "development of a number of reading clinics in which the personal and emotional problems of the reader are of prime concern."[7] This development is but one aspect of the influence of psychology upon the field of reading.

Spache traces this influence of psychology upon reading from the nineteenth century emphasis on physiology of reading to the present broad definition of reading as one aspect of the growth of the child as

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[5] Ibid., p. 48.

[6] Philip B. Shaw, "Integration of Reading Instruction with 'Regular' College Offerings," in Emery P. Bliesmer and Albert J. Kingston, Jr. (eds.), Phases of College and Other Adult Reading Programs. NRC Tenth Yearbook (Milwaukee, Wisconsin: Reading Center, Marquette University, 1961), p. 122.

[7] Alton L. Raygor, "The Influence of Psychology on the Field of Reading," in Emery P. Bliesmer and Albert J. Kingston, Jr. (eds.), Phases of College and Other Adult Reading Programs, NRC Tenth Yearbook (Charlottesville, Virginia: Jarman Printing Co., 1961), p. 50.

a whole. "Thus the ultimate goal of reading instruction became the modification of the personal and social adjustment of the reader."[8]

Obviously such broad aims demand careful application of learned principles to reading instruction. Unfortunately classroom and clinical practices have not kept pace with psychological thinking. Spache, noting the continuation of earlier practices and emphases, stated:

> The lag of classroom practices behind psychological theory probably indicates that much of our efforts for the next decade or so should be placed upon improving our instructional procedures and relating them more closely to the current explanations of the psychological nature of reading.[9]

Raygor lists several psychological concepts which are fully available at the present but not applied in the field of reading instruction. Among these are diagnostic and remedial techniques, including the diagnostic syndrome, and statistical tools. In the vital area of individual differences he feels that we have done practically nothing at the college level to fit the curriculum to the needs of the individual.[10]

A challenge to the clinician in the area of college reading was given by Spache. He reminds us of the necessity for clinicians in college reading to be concerned with variables which influence success in reading improvement. He states:

> Clinicians should be productive in identifying these factors, measuring and weighing their impact, determining the interactions among factors, and

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[8]George D. Spache, "Psychological Explanations of Reading," in Oscar S. Causey (ed.), Exploring the Goals of College Reading Programs, SWRC Tenth Yearbook (Fort Worth, Texas: Christian University Press, 1955), pp. 14-22

[9]Spache, " Physiological Explanations . . . . , p. 22.

[10]Raygor, op. cit., pp. 52-53.

observing the results of attempts to control these elements.[11]

One of the five categories of factors emphasized by Spache is that of vision and other physical factors. Yet, despite studies pointing to the role which vision plays in reading, college clinicians tend to ignore its effect upon reading. Three types of errors follow from this neglect, (1) misuse of materials and equipment in an attempt to increase eye-span; (2) misrepresentation of value of improvement courses stemming from ignorance of the physical limitations of the visual processes in reading; and (3) misjudgment of the transfer of training to daily use because of unknown vision problems. Spache states:

> In our opinion the college reading technician faces the responsibility for evaluation of student vision for the purpose of relating his findings to instructional practices. As the diagnostician, he should be able to prescribe the type of reading training which will be most feasible in view of the student's profile . . . . If his vision screening methods indicate any unusual variations in the visual profile, the clinician should also assume the responsibility for referring the student for professional examination, and utilizing the implications of that testing in planning reading training efforts . . . . In addition the college technician should convey to his reading instructors sufficient information about the visual process to prevent them from repeating . . . faulty practices . . . .[12]

While every reading clinician will concede the importance of vision in a student's reading performance, there is a tendency to ignore it in practice. There are several reasons for this neglect, (1) the need to deal with masses of students; (2) the time required to perform

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[11] George D. Spache, "Clinical Work with College Students," in College-Adult Reading Instruction, IRA Perspectives in Reading I (Newark, Delaware, 1964), p. 135.

[12] Ibid., p. 143.

adequate visual screening; (3) the relatively small number of students believed to be affected by vision problems; (4) the confused and contradictory reports of the importance of vision to reading success; and (5) the controversy among vision specialists as to what constitutes adequate correction of vision problems as a base for success in reading.

Obviously the answer to these problems lies in studies which clarify for the reading clinician the role of vision in reading. Research has indicated that the relationship between vision and reading is quite complicated. While some facts have been shown to be significant, these have not been sufficiently defined to be applicable to practice in a reading clinic.

Thus the clinician desiring to consider vision as a factor in reading is forced to make decisions based upon impressions gained through experience. In considering the visual needs of students, he may refer too many or too few to vision specialists, and either decision is wasteful in terms of professional time, money, or solution to the problem. Moreover, the report of the vision specialist may not be directed toward the student's reading needs. The culmination of such confusion is in the inadvertent recommendation that a student participate in a course of reading improvement quite likely to lead to failure and frustration.

The present study was designed to contribute to the solution of this problem by identifying vision factors and relating these to improvement in reading skills. It is hoped that the clarification of these relationships will help the clinician to test adequately the student's vision and properly apply the test results in specific situations.

Purpose of the Study

The purpose of this study was to determine the relationships between vision and change in reading skills as a result of a reading improvement course, and the effect of uncorrected vision problems upon these relationships.

As a means of studying this central purpose, the following problems were considered:

1. Identification of vision factors in a battery of twelve vision screening tests;
2. Determination of the amount of change in reading skills as a result of a reading improvement course;
3. Determination of the relationships among vision factors and changes in reading skills for all subjects;
4. Determination of the relationships among certain mental abilities and changes in reading skills as a result of a reading improvement course;
5. Determination of the relationships between previous academic achievement and changes in reading skills as a result of a reading improvement course;
6. Determination of the relationships between initial reading skills and change in reading skills as a result of a reading improvement course;
7. Identification of students who have uncorrected visual problems;
8. Determination of differences in vision factors and reading skills which are attributable to uncorrected vision problems.

An attempt was made to relate the findings of the study to the problem of counseling students in a reading clinic.

The Hypotheses

In order to fulfill the purposes of the present study, the following hypotheses were tested:

1. There are specific factors which are components of vision and which are identifiable through factor analysis of scores on a battery of vision screening tests given to college students.

2. There are positive relationships between vision factors, and change in reading skills as a result of a reading improvement course given to college students.

3. There are positive relationships between levels of certain mental abilities, and changes in levels of reading skills as a result of a reading improvement course given to college students.

4. There are positive relationships between previous academic achievement, and changes in levels of reading skills as a result of a reading improvement course given to college students.

5. There are positive relationships between initial levels of reading skills, and changes in levels of reading skills as a result of a reading improvement course given to college students.

6. The nature of vision factors, and their relationships with changes in reading skills, differ among subjects with uncorrected vision problems and the total group of subjects.

Definition of Terms

The field of vision testing and vision screening is replete with technical terms. For this reason a Glossary of Vision Terms has been prepared as Appendix A.

Other terms used in the present study which are important to clarity in the discussion of concepts are defined as follows:

1. Academic achievement potential is the predicted freshman grade-point average for a student. This predicted average was determined by the Office of Admissions prior to a student's admission to Stetson University, and is based upon measures of certain mental abilities, previous academic achievement, and other variables.

2. Change in reading skills refers to the difference between scores made on a reading pre-test and on a reading post-test. Change includes both improvement in reading skills and loss of reading skills as a result of the reading improvement course.

3. Factor is used in this study to refer to the product of the statistical procedure of factor analysis, that is, a statistically derived functional unity. Exceptions are made in direct quotations.

4. Initial reading skills refer to the levels of skills in rate of reading and in reading comprehension acquired by the student prior to the reading improvement course. In the present study, these levels of skills are measured by the Diagnostic Reading Tests, Survey Section, Form A, which was given prior to the course as a pre-test.

5. Mental abilities refer to those characteristics of the student which are measured by the Verbal section and by the Mathematical section of the Scholastic Aptitude Test prepared by the College Entrance Examination Board. These characteristics are identified, respectively, as Verbal Reasoning Ability and Numerical Reasoning Ability.[13]

6. Previous academic achievement refers to the level of attainment in academic studies relative to the peer group with which the student

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[13]College Entrance Examination Board, Scholastic Aptitude Test (Princeton, New Jersey, 1963).

attended high school. In the present study this is measured in terms of high school senior class rank.

7. Reading improvement course refers to a program of study following a prescribed curriculum, designed to improve the reading skill(s) of students enrolled.

8. Relationship refers to systematic co-relation of variables, the degree of which is usually expressed by means of a correlation coefficient. Causality is not implied in either direction, but only concomitant variation.

9. Uncorrected vision problems refer to inferred difficulties in the process of vision identified by failure of one or more vision tests presented by the Ortho-Rater. Standards are from the School Profile, a minimum standard found desirable for students and individuals who do clerical and administrative tasks. The School Profile was recommended by the Bausch and Lomb Optical Company, developers of the Ortho-Rater, for use in the University of Florida Reading Laboratory and Clinic.[14]

10. Vision refers to the complex process of seeing and interpreting external stimuli. A brief interpretation might be that it involves ocular muscle coordination, lens accommodation, light transmission through the lens to the retina, retinal impulse transmission to the brain by means of the optic nerves, fusion of the image by the brain, and perception of meaning in the image.

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[14]Bausch and Lomb Optical Company, by personal letter to Dr. George D. Spache, April 26, 1951.

Limitations of the Study

The present study was made at Stetson University, Deland, Florida, in the fall semester of 1964-65. It is assumed that results will not be seriously affected by changes occurring in the next five years. Subjects tested were determined to be the poorest readers (as identified by the Cooperative English Test, Reading Comprehension Section, Total Score)[15] in the entering freshman class. Caution must therefore be used in applying the findings to students at other levels.

Visual problems are believed by the author to be in themselves a screening factor in education. A higher percentage of academically unselected students would be expected to have uncorrected vision problems (for example, in a large northeastern university). Stetson University is a private, southern, five-year university enrolling approximately sixteen hundred students. Entrance requirements indicate its entering freshmen are somewhat more select than, that is, above the level accepted by, the large state-supported universities in Florida. Therefore, the findings of this study probably can be applied to students in selective four-year institutions and above.

Although Stetson University accepts qualified students of all races, the subjects were predominantly Caucasian. No foreign student completed the course, so interpretation is limited to English-speaking Caucasian students.

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[15]Educational Testing Service, Cooperative Test Division, Cooperative English Tests, Form IC (Princeton, New Jersey, 1960).

Of one hundred eighty students scheduled for the course, only one hundred sixty-three could be used as subjects by virtue of complete data. It is recognized that dropouts from such a course may result from many causes. The author deeply regrets such a loss, feeling that many were consciously or unconsciously reacting to vision problems. Still, conclusions should perhaps be limited in application to students who complete a similar course in reading improvement. For reasons stated above, however, it is believed that a study of the entire group of one hundred eighty students would reveal higher incidence of vision problems.

CHAPTER II

HISTORY OF THE PROBLEM

The present study has several facets, including screening of vision in educational institutions, the relationship of vision to reading, the improvement of reading at higher educational levels, and factor analysis as a research tool in studying vision and reading. This chapter attempts to give the reader an understanding of these various facets by referring to selected literature in each area.

Screening of Vision in Education

Scientific studies of the relationship of vision to reading began in Europe in the middle of the nineteenth century. Soon after its introduction in 1862, the Snellen Chart began to be used to measure visual acuity of students in schools. At this time the Chart was the only device available to determine whether or not a student had sufficient keenness of vision to read. It thus became the first accurate means for mass screening of vision in the schools.

Other early studies of vision were concerned primarily with the movement of the eye during reading. Erdmann and Dodge began crude observations by watching one eye of the reader through a telescope. The obvious difficulty with this procedure was the lack of a verifiable record. Emphasis upon securing accurate records led to the application of the photographic method, which was gradually improved until the

researcher was able to obtain a highly accurate record of the positions of the eyes during movements and pauses, and the durations of these.

Studies of eye movement during reading led to several reforms, including the shift of emphasis from oral to silent reading. Because accurate records were retained, researchers were able to "analyze the development of reading and to describe the stages of growth of the reading ability."[1]

The development of visual functions at various grades from kindergarten to eighth was demonstrated by Park and Burri. These authors noted that:

> . . . because of the lack of complete maturation in the children entering school, many indicate poor vision with little or no fusion or stereopsis, and poor duction ability. But visual maturity develops rapidly during the first two years of school.[2]

These understandings of the development of visual functions led to an accurate means for diagnosing certain problems faced by individual children in learning to read. The studies also point out a definite change in the concept of vision by a large number of specialists in vision, psychology and education. Prior emphasis, based upon nineteenth century physics, was upon the structure of the eyes, related muscles and nerves. Tests by the mechanist were made with the eyes in a static

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[1]Frank N. Freeman, "The Place of Laboratory Experiment in Educational Research," Review of Educational Research, Vol. 4 (January, 1934), p. 97.

[2]George E. Park and Clara Burri, "Eye Maturation and Reading Difficulties," Journal of Educational Psychology, Vol. 34 (December, 1943), p. 543.

position; the goal was exact monocular refraction. Correction involved glasses, medication and surgery; prevention was precluded by the theory.

In keeping with a general trend in the sciences, the new emphasis was upon the dynamics of vision. The functionalist was concerned with the psycho-physiological process of seeing as a learned task. Tests involved both monocular and binocular functions at various working distances in order to analyze interferences in binocular functions. Since patterns of seeing were learned, faulty seeing could be corrected through re-education (orthoptics).

> Prevention of visual difficulties is the keystone of the program suggested by those who emphasize the dynamics of seeing, or seeing as learned . . . the functionalist is concerned with the development of visual readiness for certain seeing tasks . . . .[3]

Betts pointed out that binocular coordination required in reading was not subject to scientific study until the development of material on visual sensation and perception and material on oculomotor habits.[4] Studies at the Shaker Heights Reading Clinic convinced Betts that binocular coordination was essential to rapid and efficient reading habits. Thus he stated:

> A one-eyed person with normal acuity . . . has little or no difficulty with the confusion of letlets and words. A two-eyed person presents a different problem; not only must the dominant eye fix on a word or phrase, but its companion also must

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[3]Emmett A. Betts and Agnes S. Austin, Visual Problems of School Children (Chicago, Illinois: Professional Press, 1942), pp. 77-78.

[4]Emmett A. Betts, "A Physiological Approach to the Analysis of Reading Difficulties," Educational Research Bulletin, Vol. 13 (June, 1934), p. 164.

> fix on the same target simultaneously and with as much precision and speed. In addition to this, the mind must fuse or combine the right-eye and left-eye images for normal perception. Many of our reading problems are traceable to a lack of coordination between the two eyes and to the probable failure of the mind to combine right-eye and left-eye pictures for proper interpretation.[5]

The need for screening tests of visual functioning in addition to the screening of far acuity by means of the Snellen Chart was shown by the Medical Department of the Shaker Heights Clinic. It was found that "approximately 90 per cent of the non-readers and severely retarded readers (required) medical attention before receiving pedagogical help."[6] These students were found to have faulty binocular coordination and astigmatism. Betts determined that seven visual items needed exploration in screening students, including (1) refractive errors, (2) muscle balance, (3) size and shape of ocular images, (4) visual fusion, (5) monocular and binocular eye movements, (6) interpupilary distance, and (7) visual imagery.

Concerned with the lack of availability of convenient tests of visual functions for researchers and educators, Betts devised the Betts Sensation and Perception Tests as a part of the Betts Ready to Read Tests.[7] Stereogram slides were placed in the Keystone Ophthalmic Telebinocular so that the left eye could see only its half, and the right eye only its half of the slide. In order to test each eye separately, one half of

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[5]Ibid., pp. 164-165.

[6]Ibid., p. 165.

[7]Emmett A. Betts, Manual of Directions for Ready to Read Tests (Meadville, Pennsylvania: Keystone View Co., 1934).

the slide was left blank of targets; in order to test binocular functions a target was placed before each eye to be fused into a single picture. In this way the eyes functioned simultaneously while the vision of either eye or of both eyes was studied.

So concerned with the need for normal visual sensation and perception was Betts that he stated:

> Before entrance to the first grade, every child should be thoroughly examined by a competent eye specialist. A certificate of visual readiness to read should be required. The number of visual aberrations among both able and disabled readers make this a mandatory policy for adoption by all school administrators.[8]

Many other researchers had voiced concern over the method of screening vision in public schools. Some authors published tests designed to improve upon the Snellen Chart. Hildreth and Axelson developed an adaptation of the Snellen Chart which was designed to motivate young children.[9] Eames made available the Eames Eye Test which measured acuity at twenty feet, and also astigmatism, coordination of the eyes, and farsightedness.[10]

Jensen[11] designed the Tests for Color-Blindness, Visual Acuity, Astigmatism which provided a measure of two-eyed vision, of color, and of astigmatism as well as of acuity. Although the Jensen and the Eames Tests

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[8]Betts, op. cit., p. 163.

[9]Gertrude Hildreth and Aljhild Axelson, "Improved Visual Acuity Tests for Young Children," Teachers College Record, Vol. 40 (December, 1938), pp. 229-236.

[10]Thomas H. Eames, "Improvement in School Eye Testing," Education, Vol. 56 (September, 1935), pp. 14-18.

[11]Milton B. Jensen, Tests for Color-Blindness, Visual Acuity, Astigmatism (New York: Psychological Corporation, 1935).

were not measuring the same visual functions and were not of equal validity (Spache[12] pointed out the problems related to each test), each was an improvement upon the single measure of acuity.

Aware that educators were dissatisfied with results of vision testing with the Snellen Chart, Oak investigated the efficiency of the Visual Sensation and Perception Tests in identifying school children who needed ocular examination. He concluded that "the Telebinocular sorts out too many cases for practical purposes and . . . misses cases needing to be referred for ocular attention."[13]

Two points should be considered with regard to Oak's study. First, the criteria against which the Telebinocular was compared were determined by a single ophthalmologist, and though apparently reliable, were not checked for validity. Second, the norms for Bett's tests were designed to screen for children with functional problems which would affect their reading, rather than for the usual criterion of "adequate" vision applied by opthalmologists. Nevertheless, Oak's data showed from 50 per cent to 75 per cent of a random sample of one hundred children failed one or more of the Telebinocular Tests, seemingly a high number.

Betts and Austin replied to the criticism of over-referral by the Telebinocular by describing a study of one hundred thirteen students:

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[12]George D. Spache, "Testing Vision," Education, Vol. 59 (June, 1939), pp. 623-626.

[13]Lura Oaks, "An Appraisal of the Betts Visual Sensation and Perception Tests as a Sorting Device for Use in Schools," Journal of Educational Psychology, Vol. 30 (April, 1939), pp. 241-250.

> When visual acuity alone is considered, the findings of this study agree in general with . . . previous investigations . . . . As findings are added to the referral routine, more cases are referred . . . . There is a cumulative effect of using certain additional tests. For example, 26.55 per cent of 113 cases were referred on the basis of acuity for distance. Additional findings from other tests increased the referrals so that when the six findings were used, 66.37 per cent of the cases were referred.[14]

Bennett, studying causal elements operating among primary grade pupils making slow progress in learning to read, concluded that "various types of visual dysfunction may sometimes contribute to difficulties in reading."[15] This conclusion supported Bett's recommendation that children who failed various vision tests be carefully studied.

Using the Telebinocular according to procedures described by Betts in the Manual of Directions, Dalton tested five thousand eight hundred twenty-one students in grades three through twelve. Only 17.6 per cent of the elementary pupils and only 12 per cent of the high school pupils passed all twelve of the tests. He concluded that "either the test shows an excessive amount of defect or . . . visual defectiveness is very prevalent among school children."[16]

Complications in visual screening.--As the relation between vision and reading became more widely recognized, more attention was given to studies which identified various vision defects in students. But these studies indicated the relation between reading and vision was

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[14]Betts and Austin, op. cit., p. 62.

[15]Chester C. Bennett, An Inquiry into the Genesis of Poor Reading, Teachers' College Contributors to Education, No. 755 (New York: Bureau of Publications, Teachers' College, Columbia University, 1938), p. 106.

[16]M. M. Dalton, "A Visual Survey of 5000 School Children," Journal of Educational Research, Vol. 37 (October, 1943), pp. 82-83.

more complicated than seen at first glance; the interpretation of results was complicated by several findings. Betts' findings that able readers also have vision problems was of particular importance.[17] It was also determined that an eye deficiency might not always be a liability. For example, Segel reported that "myopia proved advantageous to persons doing certain kinds of work and possibly in facilitating reading."[18]

A second effect complicating the relation between reading and vision is that of visual fatigue. A student might be able to control the functions of the eyes for brief periods, for example, in order to pass visual screening tests, but might be unable to operate efficiently over an extended period. Thus Betts reminds us that "given normal visual acuity . . . the student must have the power to maintain his binocular coordination during the entire period of reading."[19] In this same vein, Park and Burri stated:

> If for some reason the eyes can no longer function as a unit, fusion has a tendency to break, causing potential diplopia, and the resulting interference becomes a disturbing factor in the process of reading.[20]

Obviously involved in the fatigue effect is the motivation of the student. If the student has one or more visual problems he may control these over a given period of time, despite increasing discomfort, as

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[17]Emmett A. Betts, "A Physiological Approach to the Analysis of Reading Difficulties," Educational Research Bulletin, Vol. 13 (June, 1934), p. 163.

[18]David Segel, "Measurement of Aptitudes in Specific Fields," Review of Educational Research, Vol. 2 (January, 1941), p. 46.

[19]Betts, "A Physiological Approach . . . , p. 174.

[20]George E. Park and Clara Burri, "The Effect of Eye Abnormalities on Reading Difficulty," Journal of Educational Psychology, Vol. 34 (October, 1943), p. 540.

required by his goal. The fact that visual screening is presented as a "test" of vision is sufficient to motivate such a student to exercise control of vision problems during the brief testing period.

Carmichael and Dearborn attempted to determine the effect upon normal subjects of fatigue created by six hours of continuous reading. It is interesting to note that their data indicated a significant increase in the average Keystone Stereopsis scores.

> This increase may have been so great as to obscure completely a 'fatigue' factor, if it existed at all. But at this point the differences observed are better explained as due more to practice effect.[21]

Despite the fact that the Betts' tests did not adapt to the test-retest design, these authors concluded that prolonged visual work "does not bring about any detectable and consistent physical alteration in the visual mechanism which changes the ability of this mechanism to perform in an effective and normal way" at either the high school or at the college level.[22] It would seem, then, that marked decrement in visual functioning during sustained use of the eyes would indicate a visual problem in need of attention since it did not occur in normal subjects.

Visual screening using the Ortho-Rater.--Screening of vision was also being emphasized in industry. Imus reported a shift of emphasis "from primary concern for first aid following accidents to selection and

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[21]Leonard Carmichael and Walter F. Dearborn, Reading and Visual Fatigue (New York: Houghton Mifflin Co., 1947), p. 378.

[22]Ibid., p. 360.

classification of personnel for job placement."[23] Too, a great demand for adequate visual screening came about through requirements for rapid screening of inductees into various armed forces schools during World War II.

To fulfill such needs, other visual screening devices were produced. One such device was the Bausch-Lomb Ortho-Rater. The battery of twelve vision tests presented with this instrument was developed in part at the Statistical Laboratory for Vision Tests at Purdue University.[24] This battery of standardized precision vision tests was used by staff researchers at Purdue University as a basis for a research approach to industrial problems in vision.

The Bausch and Lomb Optical Company published profiles as minimum Ortho-Rater standards for various industrial jobs. As a service to educators, this company recommended as a School Profile the same Ortho-Rater standards as those for individuals who do clerical and administrative tasks.[25] In elementary schools about 35 per cent to 40 per cent of the students were expected to fail this standard.

Several Armed Forces studies comparing the merits of various vision screening devices were summarized by Imms. The reported

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[23]Henry A. Imms, "Testing Vision in Industry," Reprinted from the Transactions American Academy of Ophthalmology and Otolaryngology (January - February, 1949), p. 1 of reprint.

[24]S. Edgar Wirt, "Statistical Laboratory for Vision Tests at Purdue University," Journal Applied Psychology, Vol. 30 (August, 1946), p. 358.

[25]Bausch and Lomb Optical Company, forwarded with letter of transmittal to Dr. George D. Spache, University of Florida, April 26, 1951.

coefficients of reliability of the vision tests are shown in Table 1.

TABLE 1

COEFFICIENTS OF RELIABILITY OF VISION TESTS COMPILED FROM SELECTED REPORTS[a]

Test	Ortho-Rater	Sight-Screener	Tele-binocular	Clinical Tests
Far vertical phoria	.79	.61	.63	.64
Far lateral phoria	.87	.80	.75	.81
Binocular far	.88-.93	.70	-	.81-.97
Monocular far	.81-.90	.84	.78-.86	.80-.97
Depth	.83	.57	.79	.62-.72[b]
Binocular near	.84-.87	.70	.72	.67
Monocular near	.80-.90	.77	.71	.75-.78
Near vertical phoria	.73	.55	-	.74
Near lateral phoria	.81-.92	.83	.85	.90

[a]Reported by Henry A. Imus, "Testing Vision in Industry," Transactions American Academy of Ophthalmology and Otolaryngology, January - February, 1949.

[b]The Howard-Dolman Test.

According to these Armed Forces studies, the Bausch-Lomb Ortho-Rater appeared to be the most reliable stereoscopic instrument for screening vision when compared with similar stereoscopic instruments. Reliability of the Ortho-Rater compared favorably with that of clinical tests by ophthalmologists.

A thorough study of an extensive battery of commercial visual screening tests and specially constructed vision tests was conducted by Robinson and Huelsman. The purpose of the study was to select tests of vision to be related to reading achievement. Factor loadings revealed

that the Ortho-Rater was among the best measuring devices for vertical phoria, depth perception, and acuity.[26]

The controversy over visual screening in schools.--Crane and other ophthalmologists compared the results of screening by stereoscopic machines (Ortho-Rater, Telebinocular, Sight-Screener) and the Massachusetts Vision Test, using clinical tests of vision as criteria. These authors reported "all of the correlations of screening procedures with the criterion (clinical findings) are low."[27] The Snellen Chart (note: actually no Snellen Chart was used; the Massachusetts Vision Test Chart was accepted as equivalent) and Massachusetts Vision Test were "the most efficient - or least inefficient - of the procedures tested."[28]

Crane's report, which became widely known as the St. Louis Study, had the effect of reducing the number of stereoscopic screening instruments used in schools. For example, on the basis of Crane's report, the Florida State Board of Health adopted as standard procedure the use of the Atlantic City Test or the Massachusetts Vision Test rather than poloroid or stereoscopic instruments. The Committee on Conservation of Vision of the Florida Medical Association was quoted as saying:

> Instruments such as the Telebinocular, Sight-Screener, and the Ortho-Rater . . . are not suitable for school eye screening for many reasons. The worst objection . . . is that they refer for

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[26]Helen M. Robinson and Charles B. Huelsman, Jr., "Visual Efficiency of Progress in Learning to Read," in Helen M. Robinson (ed.), Clinical Studies in Reading II (Chicago: University of Chicago Press, 1953), pp. 55-59.

[27]M. M. Crane, et al., Screening School Children for Visual Defects, Children's Bureau of Publications, No. 345 (Washington, D. C.: United States Government Printing Office, 1954), p. 92.

[28]Ibid., p. 24.

> eye examinations far too many children whose eyes are normal. This has been demonstrated in controlled studies such as that of Crane . . . .[29]

Thus in Volusia County, Florida, all Keystone Telebinocular instruments previously used by visiting public health nurses were withdrawn. These public schools now utilize the Massachusetts Vision Test, "E"-Chart, screening only acuity of students at a distance of twenty feet.

Among authors who severely criticized Crane's report was Kelly, who pointed out statistical errors as well as errors in experimental design. His objections were raised primarily because the widespread reporting of erroneous conclusions from the study "handicapped the establishment of sound visual screening programs in our schools."[30]

As early as 1943, Russell, discussing the growth of the theory of interaction between vision defects and reading habits, pointed out that:

> It now forms the basis of many optometrists' practices in the adjustment of visual difficulties, and it may be that educational psychology has been afflicted with some of the conservatism of orthodox ophthalmology in its failure to study, from a fresh angle, the whole problem of relations between reading abilities and visual defects.[31]

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[29] Selection of Eye Screening Apparatus for Use in Florida Schools, Florida State Board of Health (December, 1960).

[30] Charles R. Kelly, Visual Screening and Child Development (Raleigh, North Carolina: North Carolina State Teachers College, 1957), pp. 2-11.

[31] David H. Russell, "Note on a New Theory about Visual Functioning and Reading Disabilities," Journal of Educational Psychology, Vol. 34 (February, 1943), pp. 115-120.

This difference of basic philosophy between the medical and the optometric vision specialists has created more or less an impasse in the development of visual screening programs for schools. But in general there is medical domination of school screening procedures. Spache states:

> County and state public health officials insist upon the use of the completely inadequate Snellen Chart because it fits the medical concept of the vision process.[32]

The controversy over the best method for school screening of vision, as well as the implications of such screening, has continued. Aware of the controversy, Taylor suggested screening by questionnaire.[33] Initial screening was done by classroom teachers through the Functional Readiness Questionnaire. Students referred by teachers were given The Functional Readiness Inventory, a one-hour series of tests involving the vision focus mechanism and acuity, the dynamic reactions of the divergence and convergence functions, and photographic eye-movement records. Corrective techniques were recommended for students whose functional readiness was inadequate.

Taylor reported that from a group of three hundred college freshmen, all seventy-eight who made low scores on the Advanced Iowa Silent Reading Tests "had vergence and/or focusing difficulties."

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[32]George D. Spache, "Classroom Reading and the Visually Handicapped Child," in J. Allen Figurel (ed.), Changing Concepts of Reading Instruction, IRA Conference Proceedings, Vol. 6 (New York: Scholastic Magazines, 1961), p. 94.

[33]Earl A. Taylor, Eyes, Visual Anomalies, and the Fundamental Reading Skills (New York: Reading and Study Skills Center, 1959), p. 6.

Only twenty of the seventy - eight read with the mechanical ability expected of college students.[34] Of forty-four freshmen who made satisfactory scores on the Iowa Silent Reading Tests, it was stated that:

> Over one-third of the group were found to have vergence and/or accommodative difficulties which could affect their reading performance. Reading graphs of the grojp revealed . . . twenty (less than half) were reading at the college level mechanically.[35]

Thus Taylor's data indicate from 50 per cent to 25 per cent of college freshmen have vision problems which affect their reading performance.

Rosenbloom also commented on the use of a checklist of visual symptoms by teachers to identify pupils needing professional eye care. He stated:

> Available research studies suggest that in those instances where the observations are carried out by a trained classroom teacher, the use of a carefully selected checklist of visual symptoms can be a valuable supplement in identifying visual problems.[36]

However, Spache has pointed out a solution to the choice of vision screening tests, at least at the elementary school level. He refers to the "developmental approach" which places emphasis upon careful observation of posture, perceptual-motor-skills, ocular pursuits, directionality, and visual perception. Spache states: "The developmental

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[34] Ibid., p.3.

[35] Ibid., p.3.

[36] Alfred A. Rosenbloom, Jr., "Promoting Visual Readiness for Reading," in J. Allen Figurel (ed.), Changing Concepts of Reading Instruction, IRA Conference Proceedings, Vol.6 (New York: Scholastic Magazines, 1961), p. 93.

approach offers not clinical tests of vision, but educationally prognostic tests of significance to reading teachers."[37]

The developmental approach to visual screening follows the thinking long established in industrial ophthalmology. Imus reminded that "for job placement it is not necessary that the vision screening tests predict the results of clinical tests of vision. If the test predicts performance on the job, that is sufficient."[38]

Carrying this reasoning over to vision screening at the college level, the clinician might utilize stereoscopic screening devices to predict performance in reading, rather than need for clinical vision analysis. The primary requirement of the test battery for this purpose is reliability.

In summary, it might be said that educational screening of vision has developed along two lines of reasoning. One theory, the mechanistic, emphasizes the structure of the eyes and is concerned with the condition of the eyes in a static state. The other theory, the functionalistic, emphasizes seeing as a learned function involving binocular coordination of the eyes in a dynamic state. The controversy between adherents to these theories has prevented development of an adequate method of school screening of vision. Consequently, specialists in related fields have recommended educationally prognostic tests rather than tests which predict clinical findings.

In the present study the Ortho-Rater is used in an attempt to determine its value as an indicator of functional visual readiness for reading.

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[37]Spache, "Classroom Reading . . . . , p. 93.

[38]Imus, op. cit.

Vision and Reading

If a student is to read by means of the eyes, then he must have sufficient vision to see the print and to discriminate one symbol from another. This is the first and obvious relationship between vision and reading, and it led to the use of the Snellen Chart as a means for measuring acuity of vision.

However, as specialists sought an understanding of the reading process, they naturally studied more carefully the operation of the sensory organs utilized. There developed from these studies an increasing awareness of, and understanding of, the close relationship between the reading and the vision processes.

As has been described earlier, the development of photographic records of eye movements during reading led to a better understanding of the reading process. It became obvious that if the vision mechanism were required to perform these precise movements any interference would probably retard development in reading.

For this reason educators stressed observations of pupils in the classroom to determine if symptoms of vision problems were apparent. Teachers were asked to report for testing any child who squinted, could not see the blackboard, had red and watering eyes, or other symptoms of poor vision. Such observations enabled the discovery of severe vision problems.

But the development of reading from oral to silent, from slow to rapid, from adjunct to major tool in education, changed visual requirements as well as curriculum. As greater stress was placed upon the

vision mechanism by continuous, rapid, and sustained near-point activity, specialists found more subtle vision problems affecting reading skills. For example, Bennett said, "the question of pedagogical significance is whether reading disabilities often result from minor visual defects of which pupil and teacher may continue unaware.[39]

In attempting to discover predictive relationships between vision and reading, researchers have considered (1) the total act of vision and the total act of reading, (2) specific vision problems and specific reading skills, and (3) combinations of vision problems and reading skills.

Eames emphasized the relationship between eye muscle imbalance, particularly exophoria, and reading difficulties.[40] As previously noted, Betts developed screening tests and pointed out reading problems arising from hyperopia, interpupilary distance, and other aspects of development of the visual mechanism when young children are learning to read. Betts found that about 10 per cent of severely disabled readers at the Shaker Heights Clinic had a low depth perception level, while all good readers with binocular vision passed the test for stereopsis. He concluded, "Although stereopsis itself is not essential for the formation of good reading habits, the factors involved do apparently contribute to reading success."[41]

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[39]Bennett, op. cit., p. 15.

[40]Thomas H. Eames, "A Comparison of Ocular Characteristics of Unselected and Reading Disability Cases," Journal of Educational Research, Vol. 25 (November, 1932), pp. 211-215.

[41]Emmett A. Betts, "A Physiological Approach to the Analysis of Reading Difficulties," Educational Research Bulletin, Vol. 13 (June, 1934), p. 171.

Witty and Kopel compared groups of poor readers with normal readers in grades three to six. In both groups they found similar incidence of refractive errors, lessened acuity, and lateral muscle imbalance, concluding that the one visual problem which differentiated the poor readers was "slow fusion." Despite these negative findings the authors remarked that "normal vision is indubitably essential to maximum attainment."[42]

Imus, Rothney, and Bear described a careful evaluation of vision in reading, using as subjects the entire freshman class at Dartmouth College. When the subjects were grouped according to diagnosis of ocular defects there were no significant differences among them in initial performance on reading tests, in gains on reading tests, or in academic achievement either prior to or during the college freshman year. The authors stated, "We have found no general important differences in performance of subjects grouped according to the physiological conditions of the eyes."[43]

Clark, after a survey of the literature relating to visual defects and reading disabilities, concluded that the difference was insignificant between good and poor readers with regard to the number of visual defects.[44]

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[42]Paul A. Witty and David Kopel, "Heterophoria and Reading Disabilities," Journal of Educational Psychology, Vol. 24 (March, 1936), p. 230.

[43]Henry A. Imus, John W. Rothney, and Robert M. Bear, An Evaluation of Visual Factors in Reading (Hanover, New Hampshire: Dartmouth College Publications, 1938), pp. 35-48.

[44]B. Clark, "Binocular Anomalies and Reading Disability," American Journal Ophthalmology, Vol. 23 (October, 1940), pp. 885-891.

In a study of over five thousand school children in grades one through eight, Dalton reported, "On the average there is no significant difference . . . in reading ability or in progress through the grades between pupils with defective vision and normal vision."[45]

A relatively high correlation (r = .465) between total vision scores and "corrected" reading scores was reported by Park and Burri. The authors concluded this correlation indicated "a definite relation between eye abnormalities and reading difficulties." Various eye difficulties showed different degrees of influence on reading ability. Monocular individuals had less trouble with reading, indicating that the major role of ocular defects in causing reading disability lies in disturbance of binocular vision.[46]

This finding supports the emphasis which Betts placed upon binocular functions.[47] Imus, Rothney, and Bear also pointed out that "cases of monocular or alternating vision are notoriously free from subjective troubles until attempts are made to re-establish binocular use of the eyes."[48]

Russell reported increasing emphasis upon the interaction between reading and vision. His studies led him to believe that just as visual defects may cause poor reading skills, ineffective skills and

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[45]M. M. Dalton, "A Visual Survey of 5000 School Children," Journal of Educational Research, Vol. 37 (October, 1943), p. 94.

[46]George E. Park and Clara Burri, "The Effect of Eye Abnormalities on Reading Difficulty," Journal of Educational Psychology, Vol. 34 (October, 1943), p. 429.

[47]Betts, "A Physiological Approach . . . , pp. 163-174.

[48]Imus, Rothney, and Bear, op. cit., p. 35.

habits of reading may be causes of functional visual defects. Consequently he listed as one of the important conclusions expressed by writers that many visual dysfunctions are learned.[49]

Robinson pointed to the importance of patterning in visual tests which subjects failed. For example, single failures of lateral phoria at near-point often occurred, but were considered valuable for analysis only if accompanied by failures in other tests. Failures in depth perception were, however, accompanied by other failures in all instances but one; thus in reading this seems to indicate loss of binocular coordination and to signal earlier fatigue and decrease in rate of reading.[50]

Edson, Bond, and Cook found no significant differences in reading between groups of children with normal vision and groups with defective vision. Nor was there any significant difference between the dispersions in the distributions of reading test scores for the children who passed, or who failed the different visual tests.[51]

The studies described above illustrate the wide differences of opinion to be found throughout the literature regarding the relation between vision and reading. Authors seeking guidance from study of

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[49]David H. Russell, "Note on a New Theory about Visual Functioning and Reading Disabilities," Journal of Educational Psychology, Vol. 34 (February, 1943), p. 116.

[50]Helen M. Robinson, "Visual Efficiency and Reading," in Clinical Studies in Reading I, Supplementary Educational Monograph No. 68 (Chicago: University of Chicago Press, June, 1949), pp. 105-106.

[51]W. Edson, Guy L. Bond, and Walter W. Cook, "Relationship between Visual Characteristics and Specific Silent Reading Skills," Journal of Educational Research, Vol. 46 (February, 1953), p. 455.

related literature express the feeling of confusion prevailing. After quoting examples of both extremes and mid-ground regarding the degree of relationship between vision and reading, Eberl stated, "In fact an analysis of the literature leaves one in an extreme state of confusion."[52]

Such conflicting reports from various studies have prevented conclusive statements regarding the relationships between vision and reading. Several reasons for the conflict become apparent. Probably most important is that gross defects in vision do not severely affect reading. Gross defects are readily observed and corrected where possible, or lead to compensatory adjustment on the part of the student. When the degree of ocular error is high, it is easier for the student to suppress vision of one eye, or to alternate vision.

But students with moderate vision problems will quite likely be unaware of their existence, and less aware of the effect upon academic achievement. As Imus, Rothney, and Bear state, "Slight abnormalities produce conflicts and misinterpretations of visual space and perception,"[53] problems which are much less amenable to self-analysis or to crude observation.

Further difficulty arises from the implied curvilinear relationships between some vision functions and reading skills. Unless statistical adjustments are made in handling the data, relationships are likely to be underestimated because of a cancelling effect.

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[52]Marguerite Eberl, "Visual Training and Reading," in Helen M. Robinson (ed.), Clinical Studies in Reading II (Chicago: University of Chicago Press, 1953), p. 141

[53]Imus, Rothney, and Bear, op. cit., p. 35.

These problems point out the need for careful consideration of experimental design in studying the vision-reading relationship. An example of the more sophisticated study is that by Robinson and Huelsman. The major purpose of these authors was to investigate the relationship between visual efficiency and reading progress. However, they recognized the need to first determine the adequacy of the tests to be used. A preliminary factor analysis of an extensive battery of commercial visual screening tests, along with tests constructed specifically for the study, led to selection of vision tests to be considered in this study. The authors then attempted to relate the selected vision tests to reading achievement. Five statistical procedures were applied to the data, culminating in a multiple-group factor analysis.

Seven groups of test correlation coefficients were chosen from the complete matrix of two thousand five hundred fifty-six coefficients. These groups were identified as (1) reading, (2) depth, (3) far acuity, (4) near acuity, (5) suppression, (6) fusion, and (7) vertical phoria. The authors concluded that:

> Certain visual characteristics were identified which appear to be related to reading . . . . Centroids representing reading and several aspects of visual performance appear to be related. This conclusion offers hope for identifying a pattern of visual tests which will be more valuable for screening purposes than those used in preceding research.[54]

Kelly also completed a significant study relating vision and reading. Utilizing the Keystone Telebinocular and Gates Reading Tests, Kelly studied the relationships among visual skills and reading. His

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[54]Robinson and Huelsman, op. cit., pp. 62-63.

data indicated that failure in one visual skill will often be related to failure in others, but these will not necessarily be related with poor reading skills. There was confirmation that the myoptic student is generally an above-average reader, but the very poorest groups also had more than average amounts of myopia. This relationship is felt to have been a source of confusion in findings regarding the relationship between myopia and reading skills.[55]

Hyperopia was in general related with poor reading skills, but when phoria also existed the students showed pronounced deficiencies in reading scores. However, this relationship is also confusing, since hyperopes who were exophoric at near-point were better than average of the total group.[56]

Kelly summarized the findings of the study as follows:

> Good readers tend to have the following visual characteristics: myopia; straight eyes (no lateral imbalance); good fusion or no fusion at all (monocular vision). Poor readers, on the other hand, tend to have: hyperopia; lateral imbalance; over-convergence; fusion problems. These statements are based upon many highly significant differences between reading skills of groups having each of the above visual characteristics, and average children.[57]

As a challenge to authors finding no relationship between reading and visual skills, the most significant difference reported by Kelly is noted. This was between myopic children with no lateral imbalance and hyperopic children with lateral imbalance. "These two groups differed

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[55]Charles R. Kelly, Visual Screening and Child Development (Raleigh, North Carolina: North Carolina State Teachers College, 1957), pp. 22-26.

[56]Ibid., p. 26.

[57]Ibid., p. 35.

more than a standard deviation in four-year reading proficiency scores, a difference significant at p less than .00001!"[58]

Spache and Tillman summarized related studies in literature which attempted to relate specific areas of visual defects to reading ability. Briefly, their findings are as follows:

(1) Fusion: poor fusion does not occur often, and reading scores may be normal except for slower speed; fusion problems tend to retard learning to read; good readers have good fusion or no fusion at all.

(2) Stereopsis: as such is not required for reading, but the degree of fusion necessary for its achievement contributes to acquisition of good reading habits.

(3) Phorias: findings are conflicting, but generally the child unable to converge or remain converged has reading problems. Both esophoria and exophoria are associated with poor reading scores, but usually in combination with other visual problems.

(4) Acuities, myopia, hyperopia: generally unrelated to reading, but myopes tend to be better readers than hyperopes.

(5) Suppression: partial or incomplete suppression causes serious visual handicaps in reading; complete suppression resulting in one-eyedness may improve reading ability under such conditions.[59]

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[58] Ibid., p. 36.

[59] George D. Spache and Chester E. Tillman, "A Comparison of the Visual Profiles of Retarded and Non-Retarded Readers," Journal of Developmental Reading, Vol. 5 (Winter, 1962), pp. 101-103.

In their comparison of retarded and non-retarded readers, Spache and Tillman conclude that the study:

> . . . lends definite support to the idea that defects resulting in fusion difficulties are strongly related to reading difficulty. The three significant differences found support each other in indicating a weakness in binocular acuity at near point among retarded readers.[60]

These students were found to be poorer in left-eye acuity, had marked differences in acuity between the two eyes, and failed the test of binocular acuity in significant numbers.[61]

Referring to a study of the binocular coordination of several thousand children needing corrective and remedial reading, Taylor found that 95 per cent showed a lack of sufficient coordination and fusion to carry out reading and study activities in a satisfactory manner. He states:

> This binocular control must be maintained during the dynamic act of reading. When the reader does not have an adequate amount of binocular control, accurate word recognition is discouraged in two ways. First the word form becomes less distinguishable as the reader fluctuates in his binocular control. Secondly, as the reader fights to maintain single binocular vision, an undue amount of energy is consumed. For many, this expenditure of energy results in visual fatigue and a general feeling of discomfort which, in turn, decreases the reader's ability to concentrate and increases his susceptibility to distraction.[62]

Taylor's comments seem to describe a large number of subjects approaching reading clinics for help.

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[60] Ibid., pp. 108-109.

[61] Ibid.

[62] Stanford E. Taylor, "Sensation and Perception: The Complexity of Word Perception," Journal of Developmental Reading, Vol. 6 (Spring, 1963), pp. 191-192.

To summarize, we might state that studies relating vision to reading have been numerous, but findings were conflicting. Major focus has been placed successively upon the relation of visual acuity, then refractive errors, then binocular coordination as these relate to reading. Early attempts to determine visual patterns related to reading failed, but gradually additional information has come to light which helps to explain the conflicting reports.

In the interaction between the visual and the reading processes, either process may affect the other. Gross visual defects may be corrected or compensated for, thus do not tend to affect reading skills; slight abnormalities which affect binocular functioning are related to poor reading. In addition to this curvilinear relationship, fatigue may affect visual function under sustained use, but fatigue is subject to control and dependent upon motivation. Both students and teachers may be unaware of minor vision problems or their effects upon reading.

Nevertheless, some combinations of vision skills are believed to be related to reading. Without doubt there is need for further study to clarify the still-existing confusion.

Reading Improvement at the College Level

In designing a reading improvement program at college level, one must be cognizant of the problems faced by reading specialists in such programs. In 1938 Imus, Rothney, and Bear commented that the growth of interest in the problems of reading performance at the college level was indicated by extensive literature in the field, by appointment of

individuals to direct remedial reading programs, by an increased number of courses offered, and by the number of meetings of associations devoted to the reading problems. The authors interpreted these facts as indicative of a fad which would soon die, leaving but a small residual effect upon educational procedure.[63]

Twenty-seven years later this dire prediction has not yet been fulfilled. Fortunately, there has been continued interest on the part of researchers who felt keenly the need for assisting college students to overcome what they believe is a serious problem. An indication of the serious attitude taken by college administrators is the rapid increase of reading programs offered. Shaw reported that during the 1950-60 decade there was an increase of about four hundred colleges offering reading courses.[64] Such expenditures of funds and efforts would appear to be based upon proved value rather than fad. McDonald states:

> Rapid development of remedial (corrective) reading courses for college students has been spurred by the research studies which show a close relationship between college success (academic grades) and reading abilities as measured by one or more reading tests.[65]

Reading improvement at the college level seems to be important for at least three reasons: (1) the ever-increasing load placed upon

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[63]Irmus, Rothney, and Bear, op. cit., pp. 1-2.

[64]Philip B. Shaw, "College Reading Improvement Programs of the Future," in J. Allen Figurel (ed.), Changing Concepts of Reading Instruction, IRA Conference Proceedings, Vol. 6 (New York: Scholastic Magazines, 1961), pp. 48-51.

[65]Arthur S. McDonald, "Influence of a College Reading Improvement Program on Academic Performance," Journal of Educational Psychology, Vol. 48 (March, 1957), p. 171.

students, (2) the relatively low reading abilities of college students, and (3) indications that reading courses help students improve their reading skills.

The increasing reading load placed upon a student is an attempt both to cover the rapidly expanding volume of literature in his field, and to have him cognizant of other fields. Libraries no longer number their volumes in thousands, but today hold millions of books, journals, papers, theses, bulletins, and microfilms reporting knowledge from all over the world. The task of today's student is to read and utilize them.

Yet the reading skills of today's college students are not geared to this demand. Sixty-one per cent of Carter's subjects (college freshmen) reported that their high school teachers had provided no opportunity to improve their reading skills; 70 per cent had not been taught how to critically evaluate a writer's bias and use of preconceived ideas; 68 per cent had not been taught how to read a chapter effectively.[66] Halfter and Douglass refer to two-thirds of the entering college population as "inadequate" in college-required reading skills.[67]

Earl Taylor reports that "over 30 per cent of the . . . students enrolled in colleges and universities of the country either fail or have great difficulty in meeting the demands of this type of environment."[68]

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[66]Homer L. J. Carter, "Effective Use of Textbooks in the Reading Program," Oscar S. Causey and William Eller (eds.), Starting and Improving College Reading Programs, NRC Eighth Yearbook (Fort Worth, Texas: Christian University Press, 1959), p. 156.

[67]Irma T. Halfter and Frances M. Douglass, "Inadequate College Readers," Journal of Developmental Reading, Vol. 1 (Summer, 1958), p. 52.

[68]Earl A. Taylor, Functional Readiness and School Adjustment (New York: Reading and Study Skills Center, 1956), p. 5.

The establishment of remedial and developmental reading programs has been an attempt to improve the level of ability of these students. Entwisle, reviewing reports for twenty-two reading improvement and study skills courses, concluded that such courses are usually followed by significant gains. These observed gains tend to persist, and academic performance is improved.[69]

Brown stated that improvements of from 30 per cent to 35 per cent may be expected in only five weeks of classwork in remedial reading as described in her study:

> In general the better readers improved more than the poorer readers when absolute increases are considered. Individual cases of improvement may run as high as 250 per cent or more.[70]

Other authors have pointed out that all students do not improve. Earl Taylor states:

> Obviously a great many pupils improve, but a large number cannot adjust satisfactorily in spite of improvement in reading ability. As is so often the case . . . the symptom (the reading difficulty) is given the attention while the cause is ignored.[71]

Thus, one of the problems in organizing a reading program is the selection of subjects who are most likely to make improvement in their reading and study skills. Studies indicate some students derive more from instruction than do others, but there is too little information available to suggest the reasons for such differences in progress.

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[69]Doris R. Entwisle, "Evaluations of Study-Skills Courses: A Review," Journal of Educational Research, Vol. 53 (November, 1960), p. 250.

[70]Louise Brown, "Development of Reading Rate and Comprehension," Journal of Developmental Reading, Vol. 3 (Autumn, 1959), p. 61.

[71]Sanford E. Taylor, loc. cit.

Schneyer suggested that if the reading instructor is aware of the elements associated with the progress or lack of progress in a reading program he may be of help to his students in at least two ways:

> First he will be able to select those students who are most likely to improve their reading and study skills. Second . . . the instructor may be able to help those students who seem least likely to benefit from instruction.[72]

Some of the elements impeding progress may be amenable to change, and thus poor readers may prepare themselves to improve their skills at a later time.

Types of courses.--Subjects selected for reading instruction may be considered for either (1) remedial or (2) developmental instruction. Shaw differentiates between these terms (respectively) as "a gap between a student's achievement and potential" and "a gap between a student's developed ability to meet the needs of the past and his ability to meet the more challenging demands of the present." Shaw points out that "only a limited segment of the population needs remedial instruction [while] all of a population can benefit from developmental instruction."[73] This seems to be in agreement with the thinking of Halfter and Douglass who emphasize the more advanced thinking-reading skills required at the college level.[74]

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[72]J. Wesley Schneyer, "Factors Associated with the Progress of Students Enrolled in a College Reading Program," in J. Allen Figurel (ed.), Challenge and Experiment in Reading, IRA Conference Proceedings, Vol. 7 (New York: Scholastic Magazines, 1962), p. 167.

[73]Shaw, "College Reading Improvement Program . . . , p. 50.

[74]Halfter and Douglass, op. cit., pp. 42-53.

It may be generally stated that reading improvement programs at the college level have fallen into three categories: (1) those based upon counseling policies, (2) those emphasizing training by mechanical devices, and (3) those centering instruction upon books or prepared materials. Counseling leads to discussions and evaluations of problems, and to teaching of techniques and methods. Machines are utilized for motivation and establishing "mechanical" skills. Textbooks give information on effective reading and learning, and manuals and materials provide exercises.

Recently the trend has been toward a combination of these approaches, utilizing the best features of each to accomplish a particular task. In the present study the reading improvement program is a combination, utilizing counseling and supported by mechanical devices.

Aims of courses.--However, specific results of these courses are seen to vary as widely as the aims for the courses with a great deal of disagreement as to what is desirable. As Heilman has stated:

> Educators at the college level have long been aware of the fact that many students, who otherwise have the ability to do college work, fail because of inefficient reading habits . . . . An extremely slow rate of reading is one of the problems found most frequently among inadequate readers.[75]

Thus rate of reading is a skill singled out for improvement by many courses.

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[75]Arthur Heilman, "Rapid Reading: Uses and Abuses," Journal of Developmental Reading, Vol. 5 (Spring, 1962), pp. 158-159.

Reed reports:

> A significant increase in rate of reading without change in comprehension or vocabulary [which] suggests that rate is an independent factor in the reading process. Furthermore, rate will increase as a result of training, and this increase has some degree of permanence.[76]

Heftel reports that students "who show the greatest aptitude are also the initially fastest readers and will probably profit the most from rate training."[77] In the same vein, Weeks stated that in his study, "poor students can improve greatly, sometimes the improvement being quite amazing because they were so slow to start with." On the other hand, the fact that better students tend to make even greater strides "supports the oft-presented view that our better students are loafing along unchallenged and are certainly working below capacity."[78]

Schick cautions that rate is dependent upon several variables including comprehension of materials read.[79] Thus Davis writes:

> The measurement of rate of work in reading for various purposes poses many difficult problems. Number of words read per minute is in itself a

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[76]James C. Reed, "Some Effects of Short-term Training in Reading under Conditions of Controlled Criteria," Journal of Educational Psychology, Vol. 47 (May, 1956), 262.

[77]Daniel L. Heftel, "Gains in Reading Speed Compared with Academic Aptitude and Initial Rate," Journal of Developmental Reading, Vol. 4 (Spring, 1961), p. 211.

[78]Lewis E. Weeks, Jr., "Speeding Up Reading: A Self-Help Program for College Freshmen," Journal of Developmental Reading, Vol. 3 (Autumn, 1959), p. 42.

[79]George B. Schick, "Progress and Poverty in College and Adult Reading Programs," in J. Allen Figurel (ed.), Challenge and Experiment in Reading, IRA Conference Proceedings, Vol. 7 (New York: Scholastic Magazines, 1962), p. 56.

> meaningless score. To be meaningful it must be associated with a score indicating the extent of comprehension that has been attained.[80]

One solution to this dilemma was the efficiency index suggested by Brown, obtained by multiplying rate in words-per-minute by comprehension calculated in per cent.

> The efficiency index is a usable concept . . . it tends to smooth out inconsistencies which may be introduced by systematic errors . . . when either speed or comprehension is used separately.[81]

Spache, however, notes that the concept tends to hide important information which is indicated by the separate scores.[82]

Reed notes that short-term training in reading does not yield material differences in comprehension as it does in rate.[83] Singer suggests that wherever possible the development of skill in power and rate should be alternated. "In agreement with the meaning theory of learning, understanding or power of reading should be developed first, then efficiency or speed of response next."[84] Rankin reports that his students in "the Rate-group not only read faster . . . but they also improved as much in vocabulary, comprehension, and total reading proficiency as

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[80]Frederick B. Davis, "Measurement of Improvement in Reading Skill Courses," in Emery P. Bliesmer and Ralph C. Staiger (eds.), Problems, Programs, and Projects in College-Adult Reading, NRC Eleventh Yearbook (Milwaukee: Reading Center, Marquette University, 1961), p. 39.

[81]Brown, op. cit., pp. 59-61.

[82]George D. Spache in a personal conference.

[83]Reed, op. cit.

[84]Harry Singer, "Substrata Factor Theory of Reading: Theoretical Design for Teaching of Reading," in J. Allen Figurel (ed.), Challenge and Experiment in Reading, IRA Conference Proceedings, Vol. 7 (New York: Scholastic Magazines, 1962), p. 230.

the Comprehension-group . . . ." He explains that poor comprehension may result from many factors including slow reading.[85]

The important effect of purpose in reading was discussed by Davis. Quoting studies which indicated the variation in rate resulting from change in purpose, he stated: "The measurement of rate of reading must be made under conditions that unambiguously define the purpose for which reading is being carried on."[86] Davis concluded that techniques commonly used for measuring changes in rate of reading brought about by reading skill courses have been inadequate for the purpose.[87]

As has been indicated, rate and comprehension are inseparable in the reading process. Although they may be looked upon as separate,[88] this view is pointing out that the relationship varies mathematically according to a reader's purpose.[89] Rankin has reviewed studies showing correlations ranging from -.47 to .92; such variation is to be expected in the light of flexibility of reading purpose.[90]

Still many authors debate the value of reading improvement courses emphasizing rate or comprehension singly. However, the position

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[85]Earl F. Rankin, Jr., "Sequential Emphasis upon Speed and Comprehension in a College Reading Improvement Program," Journal of Developmental Reading, Vol. 7 (Autumn, 1963), p. 53.

[86]Davis, op. cit., pp. 30-31, 36.

[87]Ibid., p. 36.

[88]Reed, loc. cit.

[89]Davis, op. cit., pp. 30-40.

[90]Rankin, op. cit., pp. 47-50.

taken in the present study is that suggested by Pauk[91] and Spache and Berg[92] that the student should strive for flexibility, that is, for control of rate and comprehension as required by purpose.

Mechanical devices.--The use of mechanical devices as aids in reading improvement programs has generated a large number of studies. Early devices such as the Metronoscope and Harvard Series of Reading Training Films led to the development of "package" programs. The Perceptoscope and the Controlled Reader are examples of these.[93] Miller, reporting practices of two hundred thirty-three colleges, indicated the most-used devices were reading accelerators, the tachistoscope, and films. The Controlled Reader, relatively new at the time, was used most often for training, but also for motivation and group drill.[94]

Some of the values of controlled reading were mentioned by Earl Taylor. These included improvement of directional attack and return sweep, reducing regressions, broadening the span of recognition, and

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[91]Walter J. Pauk, "Basic Skills Needed in College Reading," in J. Allen Figurel (ed.), Reading for Effective Living, IRA Conference Proceedings, Vol. 3 (New York: Scholastic Magazines, 1958), p. 44.

[92]George D. Spache and Paul C. Berg, Better Reading for Business (New York: Thomas Y. Crowell Co., 1958), pp. 16-17.

[92]Edmund N. Fulker, "A Decade of Progress in College and Adult Reading Improvement," in Oscar S. Causey (ed.), Significant Elements in College and Adult Reading Improvement, NRC Seventh Yearbook (Fort Worth, Texas: Christian University Press, 1958), pp. 44-48.

[94]Lyle L. Miller, "Current Use of Workbooks and Mechanical Aids," in Oscar S. Causey and William Eller (eds.), Starting and Improving College Reading Programs, NRC Eighth Yearbook (Fort Worth, Texas: Christian University Press, 1959), p. 74.

thereby reducing fixation time. In general, basic visual skills were learned and could be developed and improved through use of mechanical devices.[95]

Concern regarding overemphasis on mechanical devices is expressed by Heilman. He stated:

> In the majority of reports mechanical devices are not appendages . . . . Rather they seem to be close to the heart of the program - a major or essential part.[96]

Earl Taylor feels this indicates misuse of the devices by clinics, since it is recognized that an instrument "can neither teach reading nor replace the teacher."[97]

In the present study, the Controlled Reader was utilized to establish the experience of rapid reading with comprehension by overcoming caution, establishing confidence in dealing with vague and indistinct portions of words, and perhaps by improving visual discrimination, as suggested by Spache.[98]

Interrelation of reading skills and other variables.--Since there is a possibility of relating results of the present study with variables other than reading skills, it is appropriate to consider

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[95]Earl A. Taylor, "The Fundamental Reading Skills," Journal Developmental Reading, Vol. 1 (Summer, 1958), p. 26.

[96]Arthur Heilman, "New Challenges and Old Problems in College-Adult Reading," in Emery P. Bliesmer and Ralph C. Steiger (eds.), Problems, Programs, and Projects in College-Adult Reading, NRC Eleventh Yearbook (Milwaukee, Wisconsin: Reading Center, Marquette University, 1962), p. 212.

[97]Taylor, "The Fundamental Reading Skills," . . . , p. 29.

[98]George D. Spache, "A Rationale for Mechanical Methods of Improving Reading," in Oscar S. Causey (ed.), Significant Elements in College and Adult Reading Improvement, NRC Seventh Yearbook (Fort Worth, Texas: Christian University Press, 1958), pp. 126-127.

findings of other researchers as to these interrelations. Heftel compared gains in reading rate with academic aptitude and initial rate. After an eight-week, sixteen-session reading improvement course, college undergraduates greatly increased both rate and comprehension of reading material. The rank-order correlation between gain in narrative rate and academic aptitude was $r = .65$, $p = .01$, and between gain in study-type rate and academic aptitude was $r = .45$, $p = .05$. Students who were initially the fastest readers gained most; initially slowest readers gained least. Academic aptitude is measured by a predictive index, that is, "a combination of weighted scores from the freshman guidance examinations which correlated highest with academic success."[99]

From his study McDonald concluded that progress in reading was related to academic success since "students who completed the Cornell Reading Program significantly surpassed subjects in the control group in regard to cumulative grade point average for the three semesters of the study . . . ."[100]

In a study of an entire college freshman class, Vinyard and Massey found that "the linguistic skills of vocabulary, paragraph comprehension, and spelling are related substantially with intelligence. Each of these variables is also related substantially with scholastic success." Much of the strength of the relationships present among these linguistic skills and between the linguistic skills and scholarship was believed by the authors to be due to their common saturation with intelligence.

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[99]Heftel, op. cit., pp. 210-211.

[100]McDonald, op. cit., p. 170.

Removal of the influence of intelligence "reduces to insignificance the relation between . . . scholastic proficiency and speed of paragraph comprehension." There remained a moderate relation between vocabulary and speed of paragraph comprehension.[101] These findings were corroborated in later studies.[102]

As one might expect, the relationships among reading and non-reading variables were found to be complicated by their interaction. Bloomer demonstrated that students whose intelligence was greater than their reading ability did not improve their reading skills to the extent of students whose initial reading ability matched their intelligence. He suggested these high capacity students do not feel as sharply the need to read, tending to use other techniques for classroom success.[103]

Bloomer's data also demonstrated that while variables other than reading were affected by college reading programs and that "they change concomitantly with reading test gains and produce an increment in academic achievement, they are not related to reading test gains." He recommends a re-examination of programs to determine variables contributing to academic success.[104]

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[101]Edwin E. Vinyard and Robert B. Bailey, "Interrelations of Reading Ability, Listening Skills, Intelligence and Scholastic Achievement," Journal of Developmental Reading, Vol. 3 (Spring, 1960), p. 178.

[102]Edwin E. Vinyard and Harold W. Massey, "The Interrelation of Certain Linguistic Skills and Their Relationship with Scholastic Achievement When Intelligence is Ruled Constant," Journal of Educational Psychology, Vol. 48 (May, 1957), pp. 270-286.

[103]Richard H. Bloomer, "The Effects of a College Reading Program on a Random Sampling of Freshmen," Journal of Developmental Reading, Vol. 5 (Winter, 1962), p. 117.

[104]Ibid.

General trends which appeared in his data are reported by Kamman. Students high in aptitude or high in reading level (comprehension and vocabulary) did not improve in reading level. None of the variables (college aptitude, study habits, initial reading performance) was related to improvement in reading rate, nor did improvement in one reading skill contribute appreciably to improvement in any other reading skill.[105] The effects of motivation, interest, and personality are pointed out by Spache.[106]

One may summarize the studies of reading improvement at college level by stating that (1) courses have demonstrated their value, (2) the trend is toward a combined method of instruction, (3) results are geared to purpose and method of instruction, (4) rate of reading can be improved relatively easily, but there is less certainty of improving other reading skills, and (5) there seems to be confusion about the interrelationships among increase in reading skills and other factors generally related to student success.

In the present study the interrelationships of reading skills (rate and comprehension), academic achievement, verbal ability and mathematical ability (SAT), academic potential (PGA) and vision skills are studied.

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[105]Richard A. Kamman, "Aptitude, Study Habits, and Reading Improvement," Journal of Developmental Reading, Vol. 6 (Winter, 1963), pp. 85-86.

[106]George D. Spache, "Clinical Work with College Students," College-Adult Reading Instruction, IRA Perspectives in Reading No. I (Newark, Delaware, 1964), pp. 138-141.

Factor Analysis of Vision and Reading

As studies of vision have increased in depth, particularly by those emphasizing the dynamics of vision, it has become more obvious that many variables were involved. And in studies relating vision and reading, researchers found confusing interaction of the many variables. For this reason, reported results of these studies have created a maze of conflicting ideas and beliefs.

As Cattell has observed, in the social sciences:

> The researcher is presented with so bewildering a multitude of possible variables that unless he factorizes to find the inherent organization . . . an immense waste of effort could (and does) take place.[107]

Thus some authors have attempted to gain a better understanding of the variables and their interaction by factor analysis of their data. In this way, effort has been made to determine functionally independent variables and observe their degree of interaction.

Vision skills.--Unfortunately, there have been few studies which report factor analysis of vision skills. Studying the vision of adults, Cook reported a factor analysis of acuity and phoria measurements obtained by standard clinical techniques and by commercial screening devices. He concluded that retinal resolution (acuity) is measured, as well as, or better, by screening tests than by wall charts; lateral phoria at far-point is measured more reliably by screening instruments than by the Maddox Rod tests, a clinical device. These conclusions clearly support the use of commercial screening devices such as the Ortho-Rater.

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[107]Raymond B. Cattell, Factor Analysis: An Introduction and Manual for the Psychologist and Social Scientist (New York: Harper and Brothers, 1952), p. 16.

Cook concluded that acuity and depth tests had the following contributing factors: (1) retinal resolution, (2) lens accommodation, (3) form (letter) perception, (4) resistance to interference, and (5) depth perception. Phoria measurements indicated the following factors: (1) lateral phoria, a general factor measured best by screening devices, (2) near lateral phoria (converging efficiency), as measured by screening tests, (3) hyperphoria (vertical phoria), and (4) far vertical phoria rest (a change noted on retest).[108]

Robinson and Huelsman studied the vision of elementary school children as measured by eighteen vision screening devices. Factor analysis of test scores indicated vision functions were best measured by subtests of various test batteries, but the Ortho-Rater tests were among those with the highest loadings.[109]

Four factors related to acuity identified by highest loadings were (1) acuity, (2) differentiation between far and near acuity tests, (3) differentiation between performances by right eye, left eye, both eyes, and (4) an instrument factor. A single factor depth was extracted from measures of depth perception, while three other factors were

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[108]Ellsworth B. Cook, "A Factor Analysis of Acuity and Phoria Measurements Obtained by Commercial Screening Devices and by Standard Screening Methods," Research Project NM-003-011 (X-493), Report No. 4 (New London, Connecticut: United States Medical Research Laboratory, U. S. Naval Submarine Base, 1948), in Helen M. Robinson and Charles B. Huelsman, Jr. (eds.), "Visual Efficiency and Progress in Learning to Read," Clinical Studies in Reading II, Supplemental Educational Monograph No. 77 (Chicago: University of Chicago, 1953), p. 37.

[109]Robinson and Huelsman, op. cit., pp. 55-59.

considered artifacts. Phoria factors were not named because of the nature of the data.[110] It has been previously noted that both vertical and lateral phoria functions are curvilinear.

Despite the fact that Robinson's subjects were elementary school children and Cook's subjects were adults, important similarities appeared in their data. Three of the four acuity factors were similar, while a fourth was dissimilar because Cook included in his study tests of form perception not utilized by Robinson and Huelsman.

As indicated in Table 2, both authors identified a "general acuity" factor, called retinal resolution by Cook. The second acuity factor was related to differences between far-point and near-point testing, which Cook associated with accommodation. The fourth acuity factor seemed to be related to use of an instrument for testing, and Cook considered the factor as identifying a resistance to interference.

Robinson and Huelsman's third acuity factor was related by the authors to differences in performances among right eye, both eyes, and left eye. This has been referred to by other authors as anisometropia,[111] acuity imbalance, and fusion aiding,[112] and acuity difference.[113] Actually the factor might involve several visual problems, including (1) differences in lens function of the two eyes, such as myopia and

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[110] Ibid., pp. 56-58.

[111] Earl A. Taylor, Eyes, Visual Abnormalities and the Fundamental Reading Skills (New York: Reading and Study Skills Center, 1959), p. 101.

[112] Kelly, op. cit., p. 5

[113] Spache and Tillman, op. cit., p. 106.

hyperopia, (2) differences in size and/or shape of images of the two eyes, whether because of aniseikonia or astigmatism, (3) interference with fusion, and (4) suppression.

TABLE 2

COMPARISON OF VISUAL FACTORS IDENTIFIED BY COOK AND BY ROBINSON AND HUELSMAN

Factor	Cook	Robinson and Huelsman
Acuity factor A	retinal resolution	acuity
Acuity factor B	lens accommodation	differentiation between far-near acuity tests
Acuity factor C	form (letter) perception	differentiation between right, left, both eyes
Acuity factor D	resistance to interference	instrument factor
Depth factor	depth perception	depth
Vertical phoria A	hyperphoria	-
Vertical phoria B	far vertical phoria rest	-
Lateral phoria A	lateral phoria	-
Lateral phoria B	near phoria lateral	-

In both studies there was a factor related to depth perception. Robinson and Huelsman declined to name factors in phoria measurements, presumably because of the curvilinear nature of the relationships. Cook, it should be noted, indicated two factors in each of the planes of measurement.

Reading skills.--There has been a greater confusion of variables in studies of reading. Studies in depth have uncovered a variety

of variables, and the confusion as to their interaction is evident in related literature. Again there is need to isolate and delineate the variables.

The traditional factor analysis in the area of reading has been designated to determine the factors in reading tests. Generally subjects are given a battery of reading tests, and from the intercorrelations of scores on the many subtests the factors are extracted which account for the variability.

Langsam conducted a factor analysis of reading scores of college women on a battery of reading tests. From the twenty-one variables, five factors were extracted and interpreted as involving (1) ideas and meaning, (2) perception, (3) word fluency, (4) numbers, and (5) seeing relationships.[114]

A comprehensive battery of reading tests was administered to one hundred college freshmen by Hall and Robinson. Their analysis yielded six factors. From the loadings of these factors the authors concluded that comprehension, rate of accuracy, and verbal knowledge represent three separate aspects of reading.[115]

An analysis of scores earned by one hundred forty-one high school students on a comprehensive battery of reading tests was made by

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[114]Rosalind S. Langsam, "A Factoral Analysis of Reading Ability," Journal of Experimental Education, Vol. 10 (September, 1941), p. 62.

[115]William E. Hall and Francis P. Robinson, "An Analytical Approach to the Study of Reading Skills," Journal of Educational Psychology, Vol. 36 (October, 1945), p. 441.

Crook. An oblique rotation of the intercorrelations yielded (1) a verbal factor for power of reading and (2) a grammar factor for speed.[116]

Singer reported five factors from a factor analysis of thirty-six tests. It should be noted, however, that his study varied from the traditional in that tests were selected as appropriate to a given definition of reading. Of the five factors extracted, two involved reading comprehension and one involved rate of reading.[117]

Holmes and Singer broadened their study to include a number of domains hypothesized as being relevant to the reading process. Of the eight factors extracted from fifty-four tests, four were related to reading. One was identified as a "verbal knowledge and symbolic reasoning factor"; another was a "phonetic word-structure factor." Two perceptual factors were identified, one related to listening and the other to visual-verbal perception. When these factors were related to speed and power as separate tasks, only on the first factor were there significant loadings.[118]

The eighth factor from the Holmes and Singer study was called a mechanical interest factor, and is definitely related to Cook's "resistance to interference" factor, and to Robinson's "instrument" factor.

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[116]Frances E. Crook, "Interrelationships Among a Group of Language Art Tests," Journal of Educational Research, Vol. 51 (December, 1957), pp. 305-317.

[117]Harry Singer, Conceptual Ability in the Substrata Factor Theory of Reading (unpublished Doctoral dissertation, University of California, Berkeley, California, 1961).

[118]Jack A. Holmes and Harry Singer, The Substrata Factor Theory: Substrata Factor Difference Underlying Reading Ability in Known Groups (Berkeley, California: mimeographed at the University of California, 1961), pp. 258-259.

Although the studies described have pointed out relatively independent factors in vision and in reading, there has been little effort to relate these. Robinson and Huelsman utilized multiple-group factor analysis with data from the fifty-nine tests of vision and reading which were selected. This analysis resulted in the selection of seven groups identified as (1) reading, (2) depth, (3) far acuity, (4) near acuity, (5) suppression, as measured by binocular reading, (6) fusion, and (7) vertical phoria.[119]

These data illustrate the reduction in numbers of variables through discovery of their inherent organization as recommended by Cattell.

> The experimenter who chooses his variables on mere hunches may find that in his blindness he has taken two or more variables which are really different manifestations of the same thing.[120]

Through factor analysis it is hoped that the more pertinent variables will be isolated.

There is clearly some agreement in vision factors isolated in the studies by Cook and by Robinson, and among authors who have isolated factors in reading. Confusion of factors isolated is seen to be in part related to the tests used to gather data, and to the method of handling data. Confusion has been related to limitations of early methods of factorization. It is believed that these limitations are overcome in the present study.

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[119] Robinson and Huelsman, op. cit., p. 61.

[120] Cattell, op. cit., p. 16.

Because of the difficulty of interpretation of the relationships of the factors reported and the reading skills, the present study has been designed to minimize the number of factors in this area. A single reading test was administered, with subtests measuring comprehension and rate of reading. These skills have been found to be relatively separate functions of reading.

Summary

The screening of vision in an educational setting has developed parallel to an understanding of the reading process and its relation to vision. In the latter half of the nineteenth century emphasis was upon visual acuity, since it was recognized that a student must be able to see well enough to differentiate letters. Screening for this purpose was adequately accomplished through the use of the Snellen Chart.

As experimentors understood the movements of the eyes during reading, emphasis began to be placed upon more subtle vision problems which might interfere with reading. Some authors emphasized seeing as a learned function, and recommended screening for prevention as well as for correction of vision and reading problems.

It was not until the stress of modern education upon the vision mechanism became apparent in the performance of "good readers" that real emphasis was placed upon visual screening. Still, the basic differences in philosophy between vision specialists emphasizing mechanics and function of the eyes has created an impasse in the development of an adequate vision screening method for education.

Specialists from related fields have continued to point out the need for comprehensive visual screening. Recently these recommendations have specified educationally prognostic tests of vision rather than tests designed to predict clinical findings.

It is primarily upon the relationship between vision and reading that the educator's interest is based. Studies have shown the development of reading affected by the development of vision in students. Whether at primary or college level, both good and poor readers have vision problems likely to affect their reading efficiency.

But the intricacy of the relation between reading and vision has become apparent in the conflicting reports from many researchers. The multitude of variables involved, as well as their interaction under varying circumstances, has led to considerable confusion among specialists of all fields.

A promising method for discovering the functionally independent variables in vision and reading, as well as their degree of interaction, is factor analysis. Some progress has been made in extracting vision factors and reading factors. Unfortunately, few studies have related the two groups of factors.

The present study is an attempt to isolate vision factors in one commercial vision screening battery, relate these factors to improvement in vision skills as the result of a reading improvement course, and note the effect of uncorrected vision problems. Other factors generally associated with student success will also be related to improvement in reading skills and to vision factors.

CHAPTER III

PRELIMINARY STUDIES

The author's interest in vision has developed over a period of years, and includes a Master's thesis[1] in the area of visual discrimination. Interest in the relationship between vision and reading came about through the experience of working with school children.

While studying the educational problems of school children, particularly at the elementary level, the author was impressed with the frequency of unresolved reading problems. All too often a catch-all label such as "emotional block" or "brain damage" was attached to an otherwise capable student who did not achieve as expected in reading. In an effort to determine reasons for these failures, the author sought assistance from various sources including vision specialists. The confusion of ideas in the area indicated a need for study to determine more exactly the relationship between vision and reading. While visual problems could not explain all reading problems, there was no doubt some influence which was not being considered in educational diagnosis.

A review of the literature emphasized that reading problems are present among both good and poor readers. Depending upon the severity of the vision problem, both educators and students might remain

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[1]David E. Edgar, "Visual Discrimination: Unequal Variation of Critical Components of Visual Stimuli" (unpublished Master's thesis, Southern Methodist University, Dallas, Texas, 1953).

unaware of the effect upon efficiency of learning. Obviously many students do succeed and many do fail, but the role of vision remained unknown in this division.

In the author's opinion, vision seemed to be a selective factor in the success of students throughout their school careers. Vision seemed to affect a student's success in beginning reading, his adaptation to the academic environment, and his consequent attainment of an educational level appropriate to his ability.

Preliminary Study A

In the summer of 1963 a group of one hundred eight students participated in an eight-week program at Stetson University. The course was designed to be an introduction to the demands of college studies. The students were of two levels: (1) high school graduates not yet accepted by a university because of poor academic achievement, and (2) high school juniors of outstanding achievement who were being considered for early admission to the University.

The program offered these students was extremely flexible in terms of courses taken, whether or not credit was desired, and whether or not admission to the University was desired. One requirement for all students was participation in the Reading Improvement Course. This course consisted of lectures, workbook exercises, and the Controlled Reader program, HsC Level.[2]

The Controlled Reader program consisted of forty filmstrips which presented to the group narrative reading materials at the high

[2] Educational Development Laboratories, Inc., Huntington, New York, 1958.

school-college level of reading difficulty. The rate of presentation was determined by the instructor, using as a criterion the successful comprehension of materials by the majority of students. Comprehension was measured immediately following each filmstrip presentation by means of a standard ten-item multiple-choice test covering main ideas and details.

A small number of students consistently failed, that is, answered less than 70 per cent of the test items, half or more of the daily comprehension tests accompanying the filmstrips. Investigation revealed that these students had scored low on the initial reading test, and that some complained of vision symptoms while reading. It was hypothesized that vision problems might be a cause of minimal reading progress.

Visual screening, using the Keystone Telebinocular, indicated that only four of the twenty-five students tested were able to pass all vision tests. This incidence of vision difficulty is much greater than one might expect in a college freshman population, and indicates a definite relation between vision problems and lack of progress in a machine-oriented reading improvement program.

The emphasis upon machine-orientation is deliberate. The average gain in vocabulary and rate for the "vision problem" group, as measured by a standardized reading test,[3] was greater than that for the entire student group. Seemingly the reading problem was associated with comprehension or rate of reading material presented by machine at far-

[3]The Nelson-Denny Reading Test, Houghton Mifflin Co., Boston, Massachusetts.

point. Obviously this tentative conclusion cannot be supported, since visual screening was not carried out for the entire group.

Table 3 indicates the number of students who failed each Telebinocular subtest. Analysis of the vision problems of these students indicates the majority of failures were on the fusion subtest. More than one-third of the students failed one or more phoria subtests, but few students had uncorrected acuity problems. It is interesting to note that vision problems ranged in difficulty from use of old prescriptions to complete suppression of one eye because of vertical phoria.

TABLE 3

NUMBER OF STUDENTS FAILING EACH TELEBINOCULAR SUBTEST (N=25)

Phoria		Acuity	
Vertical, Far	3	Right, Far	2
Vertical, Near	3	Right, Near	0
Lateral, Far	3	Left, Far	0
Lateral, Near	9	Left, Near	0
Fusion		**Stereopsis**	
Fusion, Far	10	Stereopsis	1
Fusion, Near	20		

Preliminary Study B

In the summer of 1964 a group of thirty-eight secondary students from the Gainesville, Florida, area public schools participated in a reading improvement program at the University of Florida Reading Laboratory and Clinic. The students attended one-hour sessions two afternoons per week for six weeks, but were allowed to remain in the Clinic as long as they desired to utilize the equipment.

The subjects ranged in grade level from ninth to twelfth grades. All work was individual and voluntary. The instructor made recommendations on the basis of pre-tests and remained available for consultation. Although recommendations were made, no effort was made to ensure completion of an assignment, and students were often observed doing work which appealed to them more.

The course could include assignments in texts on reading and study skills, and exercises in reading and vocabulary workbooks. There were exercises in prepared folders in the areas of Rapid Reading, Reading in the Content Fields, Spelling, Word Study, and Work Habits. Also available were the SRA Reading Laboratory[4] and the EDL Controlled Reader programs for junior high and high school-college levels.

An attempt was made to predict failure of vision screening tests by utilizing the following criteria: (1) beginning reading level, (2) beginning rate, and improvement in comprehension and rate on the Controlled Reader, and (3) number of sessions on the Controlled Reader. Beginning reading level was measured by the Diagnostic Reading Test, Survey Section Form F,[5] and included measures of rate of reading, story comprehension, paragraph comprehension, and vocabulary. Beginning rate on the Controlled Reader was assigned by the instructor on the basis of the reading pre-test score.

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[4]Science Research Associates, Chicago, 1957.

[5]Committee on Diagnostic Reading Tests, Inc., Mountain Home, North Carolina, 1950.

Thirty-one of the students were available for visual screening with the Bausch-Lomb Ortho-Rater and the Spache Binocular Reading Test.[6] Predictions were made by the author without knowledge of visual screening results. The results of the predictions are presented in Table 4.

TABLE 4

PREDICTIONS OF VISUAL PROBLEMS COMPARED WITH ACTUAL FAILURES OF VISUAL SCREENING TESTS

Prediction	No test failed	One or more tests failed	Questionable vision	Total
Correct	16	1	2	19
Incorrect	4	3	5	12
Total	20	4	7	31

In general, the predictions were incorrect more often than if visual problems were ignored. Predictions were correct 60 per cent of the time, when vision problems were considered, but would have been correct 67 per cent of the time if visual problems were ignored. It was predicted that thirteen students would fail vision screening tests; four students actually failed, and seven students had questionable scores on one or more vision tests.

Further analysis of the data revealed the following variables which affected the predictions:

(1) Age and grade of students, which determined previous training in reading and affected

[6] Keystone View Co., Meadville, Pennsylvania, 1955.

level of skill development, thus the subject's abilities to utilize filmstrips of the difficulty used;

(2) Students controlled their own work which, when related to interest, attitudes, and personality, seriously affected the number of filmstrips read and amount of work done;

(3) Filmstrip projection was at near-point, requiring consideration of different vision variables from those used when far-point projection is presented;

(4) Experience of the clinician with specific populations seriously affects the quality of the predictions.

Discussion of the Preliminary Studies

These studies pointed out several problems involved in the relationship between vision and reading. In Study A, students were able to show improvement on a standardized reading test despite failure to show improvement on daily exercises using the Controlled Reader. This implies that vision problems may interfere with certain types of reading activities and not with others. Students may also have been able to control vision problems during testing which are relatively minor but which interfere with daily reading activities.

It is significant to note, however, that college students exhibit all levels of vision problems. Two subjects were unaware that they were suppressing the vision of one eye; other students were "getting by" with prescriptions long out of date and inadequate. Some students were contact lenses for cosmetic purposes despite resulting diplopia or distracting discomfort. But most students with vision problems were

unaware of their possible effect upon their academic progress, and were unaware of any solution to the dilemma.

Study B pointed out the great need for careful experimental design in studying the relationship between vision and reading. The experimenter must select subjects carefully, standardize the method of instruction, and utilize a refined statistical procedure.

Most important, however, is the indication of need for basic research to identify both vision variables and reading variables, and to discover the degree and type of interrelation among them.

CHAPTER IV

DESIGN OF THE EXPERIMENT

Briefly, this study is designed to discover (1) the relationships which exist between vision factors derived from a battery of vision screening tests, and change in reading skills resulting from reading improvement instruction, and (2) the effect of uncorrected vision problems upon these relationships.

From the entering freshman class at Stetson University one hundred eighty subjects were chosen, on the basis of relatively low reading skills, to participate in the present study. These subjects were given a reading test to discover initial level of reading skills. A reading improvement course was then given to all subjects. A reading post-test indicated change in levels of reading skills as a result of the course. Individual tests of vision skills were measured using the Ortho-Rater.

The present chapter will describe (1) the subjects and the method of selection of these subjects, (2) the tests selected and the administration of these tests, (3) the Reading Improvement Course given to all subjects, and (4) treatment of the data.

Subjects

The subjects of this study entered Stetson University, Deland, Florida, as freshmen in the fall of 1964. The entire entering freshman class was given the Cooperative English Tests, Form IC (college level)[1] as a part of the regular freshman orientation procedure. A tentative selection of two hundred thirteen students was made on the basis of a cutoff score of one hundred sixty-five on the total Reading Comprehension scale. This was approximately the lower 40 per cent of the freshman class in reading skills, as selected by the Cooperative English Tests, Reading Comprehension section.

Those students who were selected as low in reading skills were notified of their scores, and rank in class with relation to reading skills. The Reading Improvement Course was announced, and the students advised that they could be required to attend. However, a second reading test was to be administered, and students who scored high and who did not desire to attend the Reading Improvement Course could be dismissed by the course instructor.

The tentatively selected students were then given the Diagnostic Reading Test, Survey Section: Upper Level Form A.[2] One hundred eighty students were finally selected for the Reading Improvement Course on the basis of relatively low scores on the Cooperative Reading Test, relatively low scores on the Diagnostic Reading Test, and willingness to

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[1]Educational Testing Service, Cooperative Test Division (Princeton, New Jersey, 1960).

[2]Committee on Diagnostic Reading Tests, Inc., Mountain Home, North Carolina, 1950.

attend the course. The one hundred eighty subjects selected consisted of eighty-five males and seventy-eight females. Their average age was eighteen; average Verbal Score on the Scholastic Aptitude Test (SAT) was 78.3649 (raw score) and average Quantitative Score on the SAT was 92.6041 (raw score).[3]

Of the one hundred eighty students who began the Reading Improvement Course, one hundred sixty-three became the subjects for the present study because complete data were available. Eighty-five were males and seventy-eight were females. Seventeen students could not be used as subjects because they either did not attend a sufficient number of class periods, did not take the visual screening test, or were absent when the reading post-test was administered.

Tests

As has been previously mentioned, the Cooperative English Test is a regular part of the freshmen orientation proceedings at Stetson University. These tests were recorded on IBM answer sheets, and machine scored and checked. Scores were punched on the individual pupil data cards, which were the source of information for this study. Initial selection of students low in reading skills was made on the basis of the Total Reading Comprehension score.

The Cooperative English Test is recognized as a well-conceived and well-executed test "within the limits of its objectives."[4]

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[3]College Entrance Examination Board, Scholastic Aptitude Test, administered by Educational Testing Service (Princeton, New Jersey, 1963).

[4]J. B. Stroud, "Reading Comprehension: Cooperative English Test," Review No. 497, in Oscar K. Buros (ed.), The Third Mental Measurements Yearbook (New Brunswick: Rutgers University Press, 1949), p. 526.

Reliability is reported as better than .90 for total score by Bear who stated:

> These are among the best [tests] for measuring reading comprehension of the usual types of subject matter but should be supplemented by some other test if measures of the pupils' usual rates are desired.[5]

The second reading test administered was the Diagnostic Reading Test, Survey Section: Upper Level Form A. This test was designed to give a relatively brief indication of reading abilities. The time required for administration of all three subtests is forty minutes, with Story Comprehension requiring fifteen minutes, Vocabulary requiring ten minutes, and Paragraph Comprehension requiring fifteen minutes.

The Story Comprehension subtest consists of a story in the area of biological science, to be read by the student within seven minutes. Rate of Reading is measured by noting the number of lines read in the first three minutes. Students are then allowed eight minutes to answer twenty multiple-choice questions about the content. Number of correct answers is used as the measure of Story Comprehension. Rate of Reading is computed by converting number of lines read in three minutes to words-per-minute, by means of a table provided.

The second subtest of the Diagnostic Reading Test is a measure of Vocabulary. The subtest consists of sixty items, wherein the student is required to fit one of five given words to a given definition. Relative ranking of the students by raw score on this subtest was used as a

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[5]Robert M. Bear, "[illegible] Comprehension: Cooperative English Test," Review No. 497, in Oscar K. Buros (ed.), The Third Mental Measurements Yearbook (New Brunswick: Rutgers University Press, 1949), pp. 525-526.

diagnostic measure, but the scores otherwise formed no part of the data. This decision was made because the Vocabulary subtest is seen to be highly affected by rate of reading.[6]

The third subtest of the Diagnostic Reading Test is a measure of Paragraph Comprehension. The student is required to read four selections consisting of one or more paragraphs. Each selection is followed by five multiple-choice questions, which test the reader over the content of the paragraph(s). Number of correct answers from the possible twenty items is used as a measure of Paragraph Comprehension.

As has been previously noted, the Diagnostic Reading Test, Form A, was used as one criterion for selection of students to participate in the Reading Improvement Course. This test also served as a reading pre-test, that is, a measure of the levels of reading skills which each subject had attained prior to participating in the Reading Improvement Course.

The Diagnostic Reading Test, Survey Section, Form D, was used as a reading post-test, that is, as a measure of the levels of reading skills for each subject after participating in the Reading Improvement Course. The differences between the raw scores on the relative subtests were used as a measure of change in levels of reading skills as a result of participation in the Reading Improvement Course.

Turnbull reported that the rate and comprehension subtests of the Diagnostic Reading Test, Survey Section, have a reliability of about .80, while the Vocabulary subtest has a reliability of about .85. He

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[6]Reed, loc. cit.

summarizes his comments by stating, "the Survey Section stands already as one of the better instruments for the evaluation of over-all reading ability."[7] Weitz cautioned that the subtest scores of the Survey Section of the Diagnostic Reading Test might not be sufficiently reliable for individual diagnosis.[8]

The battery of twelve tests used to screen vision was designed as Occupational Vision Tests to be used with the Ortho-Rater.[9] This battery of tests was developed and validated by the Bausch and Lomb Scientific Bureau in collaboration with the Statistical Laboratory for Vision Tests at Purdue University. The standardized vision tests were then used as a basis for routine and special studies of vision in industry.[10]

As previously noted in Chapter II, the Ortho-Rater test battery is highly reliable and valid when compared with other stereoscopic vision screening instruments.[11] For this reason, educators and clinicians

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[7]William W. Turnbull, "Diagnostic Reading Tests," Review No. 531, in Oscar K. Buros (ed.), The Fourth Mental Measurements Yearbook (Highland Park, New Jersey: The Gryphon Press, 1953), p. 572.

[8]Henry Weitz, "Diagnostic Reading Tests," Review No. 531, in Oscar K. Buros (ed.), The Fourth Mental Measurements Yearbook (Highland Park: The Gryphon Press, 1953), p. 575.

[9]Bausch and Lomb Optical Company, Rochester, New York, 1944.

[10]Wirt, loc. cit.

[11]Henry A. Imus, "Testing Vision in Industry," Reprinted from the Transactions American Academy of Ophthalmology and Otolaryngology (January - February, 1949), p. 2 of reprint.

became interested in its use as a vision screening device in schools. Bausch-Lomb recommended a School Profile for use with adult students which was identical with norms for individuals doing clerical and administrative tasks in industry.

Robinson and Huelsman, in a thorough study of commercial visual screening devices for use with school children, found the tests presented by the Ortho-Rater to be among the best measuring devices for those visual abilities they are intended to measure. This conclusion was based upon a factor analysis of fifty-nine tests of vision.[12]

Each of the twelve tests presented by the Ortho-Rater is designed to represent one aspect of visual performance or of visual skill. The skills measured and the sequence of presentation are listed below:

Far-Point	Near-Point
1. Phoria, Vertical	8. Acuity, Both
2. Phoria, Lateral	9. Acuity, Right
3. Acuity, Both	10. Acuity, Left
4. Acuity, Right	11. Phoria, Vertical
5. Acuity, Left	12. Phoria, Lateral
6. Depth	
7. Color Discrimination	

Tests at far-point are at the optical equivalent of eight meters (about twenty-six feet) from the subject; tests at near-point are at the optical equivalent of fourteen inches from the subject.

There are six tests of acuity, all of which are administered without closure or occlusion of either eye, by means of separate, but fusible, test fields. The three acuity test slides are duplicated, except for target location, at far-point and near-point. "These tests

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[12]Helen M. Robinson and Charles B. Huelsman, Jr., "Visual Efficiency and Progress in Learning to Read," in Helen M. Robinson (ed.), Clinical Studies in Reading II (Chicago: University of Chicago Press, 1953), pp. 40-50.

classify subjects finely at both high and low levels of acuity. Approximately normal distributions may be expected on all of these acuity tests."[13] Scores on these subtests range from zero through fifteen. Vision acuity equivalents of the levels of these tests are indicated in Appendix B.

There are four tests of phoria, two presented at far-point, and two at near-point. Each of the tests of phoria extends from one extreme through the normal to the other extreme. The tests of vertical phoria are calibrated in steps of one-third prism diopter in the mid-range, and one-half prism diopter toward both ends of the range. The test of lateral phoria is calibrated in units of one and one-half prism diopters. Approximately normal distributions are to be expected from all four phoria tests.

The test of Depth Perception is made only at far-point. Units of measurement are unique to the test, and are not equal, since they classify subjects more finely at the more difficult levels.

The test of Color Discrimination is also made only at far-point. The test classifies subjects finely only at low levels of color discrimination ability.

The norms for all Ortho-Rater tests have been established by the technique of determining cutoff scores to eliminate the largest number of poor achievers. As such, these norms do not attempt to predict success or failure on corresponding clinical tests.

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[13]Bausch and Lomb Optical Company, Standard Practice in the Administration of the Bausch and Lomb Occupational Vision Tests with the Ortho-Rater (Rochester, New York: A589, III, 49, 1944), p. 6.

The Ortho-Rater tests of vision were administered by appointment to individual subjects. The time required to administer each test was about twenty minutes. In administering the Ortho-Rater tests of vision, standard practice was followed where subjects wore corrective lenses. If glasses were worn all the time, all tests were made with the subject wearing the correction. If glasses were worn only for reading, only near-point tests were made while the subject wore the correction. If glasses were worn only for distance, only far-point tests were made while the subject wore the correction. Special attention was given to record the point of stabilization of the arrow in the lateral phoria tests. Scores on the Ortho-Rater Tests were recorded on a specially designed Individual Vision Profile (see Appendix B).

The Reading Improvement Course

The Reading Improvement Course consisted of twelve class periods of approximately fifty minutes each. The students were allowed to enter one of six groups which met three afternoons per week. Each group of approximately thirty students attended three class periods per week for four successive weeks.

The first half of each period was devoted to rate increase. A total of twenty-four filmstrips was presented using the EDL Controlled Reader, High School-College Series.[14] Each filmstrip was followed immediately by a standard ten-question test of comprehension. Answers were recorded on a prepared answer sheet (see Appendix B). Each

[14]Educational Development Laboratories, Huntington, New York, 1958.

student scored his own test as soon as it was completed. Filmstrips were presented to the group at a rate of reading determined by the instructor. Although an attempt was made to increase the rate by twenty-five words per minute for each filmstrip, successful comprehension by the majority of the group was considered.

The goal of the rate training was freely discussed with the students. It was hoped to have each student achieve a 50 per cent increase in word-by-word reading of narrative material. The problem of transferring rate increase from projected material to textbook reading was discussed, and suggestions for practice were made.

The second half of each class period was devoted to instructions in reading flexibility. Lectures and demonstrations helped explain various methods of selective reading. Study techniques were discussed as these apply to the various content fields. An attempt was made to have each student practice the utilization of purpose to determine method of reading in his daily work.

The slowing effect of continuous study was explained, and recommendations made for counteracting this effect. The techniques of selective reading for specific types of comprehension were demonstrated, and practiced. Subjects were requested to practice, at first, on materials other than regular class assignments; later, practice was requested on class assignments.

During the entire Reading Improvement Course emphasis was made upon comprehension geared to a selected purpose utilizing a specific method or methods of reading.

Treatment of Data

Because of the confusion which has accompanied attempts to relate vision and reading, it was decided to identify through factor analysis the significant variables operating. Other statistical methods have failed to identify those variables which are significant, and failed to indicate the degree of interaction of variables.

Factorization was therefore used in an attempt to obtain "a new order of variables and concepts on the relations among which . . . to begin forming hypotheses . . . ."[15] In this way an effort was made to determine functionally independent factors as the source of discussion of data, rather than intuition.

Vision variables.--Since tests of phoria measure muscle imbalance on either side of a theoretical "normal" posture of the eyes, each of the tests of phoria presented by the Ortho-Rater extends from one extreme of the scale through the normal to the other extreme of the scale. Raw scores from these tests would thus present a U-shaped pattern when plotted along some measure of usable binocular vision.

In order to minimize this curvilinearity, the raw scores from phoria tests were rescaled as deviations from an assumed best, or normal score (see Individual Vision Profile, Appendix B). These deviations indicate a degree of imbalance of the habitual posture of the eyes at the distance represented.

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[15]Raymond B. Cattell, Factor Analysis: An Introduction and Manual for the Psychologist and Social Scientist (New York: Harper and Brothers, 1952), p. 17.

In the vertical phoria, the normal score is taken to be 5, the center of the test scale, and scores toward either extreme of the scale indicate muscle imbalance in the vertical plane (hyperphoria). In lateral phoria, the normal score was taken as 8, the center of the test scale, with scores toward either extreme of the scale measuring muscle imbalance in the lateral plane (esophoria and exophoria).

Four phoria deviation scales were derived in this way: (1) Vertical Phoria Deviation Far, (2) Vertical Phoria Deviation Near, (3) Lateral Phoria Deviation Far, and (4) Lateral Phoria Deviation Near (see Table 5).

Similarly, tests of acuity measure on either side of what is considered normal vision. Normal vision is usually taken to be 20/20 on the Snellen Scale, and corresponds to the raw score 10 on the Ortho-Rater acuity tests.[16] Deviation scores are therefore any score below normal, or above normal acuity.

There is not the same meaning attached to the normal acuity measure as to the normal phoria measure. There is no true biological normal acuity, but this is more an average score. There is, however, the confusion surrounding the problems of hyperopia and myopia which clinical experience has indicated to be significant in the relationship between vision and reading. The acuity deviation scales are an attempt to eliminate the effects of hyperopia and myopia.

Six acuity deviation scales were derived in this way: (1) Acuity Deviation Both Far, (2) Acuity Deviation Right Far, (3) Acuity

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[16]Visual acuity equivalents of the levels of these tests are indicated in Appendix B.

Deviation Left Far, (4) Acuity Deviation Both Near, (5) Acuity Deviation Right Near, and (6) Acuity Deviation Left Near (see Table 5).

As mentioned above, researchers have pointed out the significance of hyperopia and myopia in relation to reading achievement. The Hyperopia-Myopia variable is an attempt to measure the difference between these two tendencies in each subject.

Myopic tendency is obtained by adding acuity deviations below 10 on all scales at far-point to acuity deviations above 10 on all scales at near-point. Hyperopic tendency is obtained by adding acuity deviations above 10 on all scales at far-point to acuity deviations below 10 on all scales at near-point. The Hyperopia-Myopia variable is the difference, that is, hyperopic tendency minus myopic tendency.

A positive score indicates pure hyperopia, that is, acuity deviations which have been reduced by the amount of myopic tendency. A negative score indicates pure myopia, that is acuity deviations which have been reduced by the amount of hyperopic tendency. However, in the study all signs have been eliminated in the factor analysis to minimize the curvilinear relation.

Thus the Hyperopic-Myopic variable is a purified deviation from normal vision, from which has been eliminated the effects of (1) poor over-all acuity and (2) excellent over-all acuity (see Table 5).

Because of the importance ascribed to "acuity imbalance" by Kelly[17] and to "acuity difference" by Spache and Tillman[18] an Acuity Imbalance variable was determined at both near-point and far-point. Acuity Imbalance Far is the difference between the raw scores on the Acuity, Right Eye and the Acuity, Left Eye subtests given at far-point. Acuity Imbalance Near is the difference between the raw scores on the Acuity, Right Eye and the Acuity, Left Eye subtests given at near-point (see Table 5).

Non-vision variables.--Three variables were taken from the Diagnostic Reading Test, Survey Section: Upper Level Form A, which was given as a reading pre-test. The test was given to determine the levels of reading skills which each subject had attained prior to participating in the reading improvement course. These variables are (1) Reading Rate, (2) Reading Story Comprehension, and (3) Reading Paragraph Comprehension.

The Reading Rate variable consists of the rate of reading in words-per-minute at which each student read the material presented in the Story Comprehension subtest during the three-minute timed period. The Reading Story Comprehension variable is the raw score from the Story Comprehension subtest, that is, the number of correct answers attained on the questions involving story comprehension.

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[17]Charles R. Kelly, Visual Screening and Child Development (Raleigh, North Carolina: North Carolina State Teachers College, 1957), p. 2.

[18]George D. Spache and Chester E. Tillman, "A Comparison of the Visual Profiles of Retarded and Non-retarded Readers," Journal of Developmental Reading, Vol. 5 (Winter, 1962), p. 108.

TABLE 5

VISION VARIABLES, AND VISION TESTS FROM WHICH DERIVED

Variable number	Variable name	Vision tests from which derived
4	Vertical Phoria Deviation, Far	Vertical Phoria Test, Far-point, deviation from 5
5	Vertical Phoria Deviation, Near	Vertical Phoria Test, Near-point, deviation from 5
6	Lateral Phoria Deviation, Far	Lateral Phoria Test, Far-point, deviation from 8
7	Lateral Phoria Deviation, Near	Lateral Phoria Test, Near-point, deviation from 8
8	Acuity Deviation Both, Far	Acuity, Both eyes, Far-point, deviation from 10
9	Acuity Deviation Both, Near	Acuity, Both Eyes, Near-point, deviation from 10
10	Acuity Deviation Right, Far	Acuity, Right eye, Far-point, deviation from 10
11	Acuity Deviation Right, Near	Acuity, Right eye, Near-point, deviation from 10
12	Acuity Deviation Left, Far	Acuity, Left eye, Far-point, deviation from 10
13	Acuity Deviation Left, Near	Acuity, Left eye, Near-point, deviation from 10
14	Acuity Imbalance Far	Raw score difference between acuity, Right eye, Far and acuity, Left eye, Far-point
15	Acuity Imbalance Near	Raw score difference between acuity, Right eye, Far and acuity, Left eye, Near-point
16	Hyperopia-Myopia	Hyperopic tendency minus Myopic tendency, utilizing six acuity scales

The Reading Paragraph Comprehension variable is the raw score from the Paragraph Comprehension subtest, that is, the number of correct answers attained on the questions involving paragraph comprehension. These variables were intended to represent the level of reading skills attained prior to reading instruction (see Table 6).

The Diagnostic Reading Test, Survey Section: Upper Level Form D was given as a reading post-test to determine change in reading skills as a result of the Reading Improvement Course. Three variables were derived from the differences between the reading pre-test and the reading post-test scores. These variables were (1) Rate Change, (2) Story Comprehension Change, and (3) Paragraph Comprehension Change.

Thus Rate Change is the difference (loss or gain) between reading rate on the pre-test and reading rate on the post-test. Story Comprehension Change and Paragraph Comprehension Change were derived in the same way. These variables were intended to represent change in reading skills attributable to the Reading Improvement Course (see Table 6).

Four additional variables were derived from the records in the Admissions Office of Stetson University. These variables were (1) Class Rank, (2) Scholastic Aptitude Test (SAT) Verbal, (3) Scholastic Aptitude Test (SAT) Mathematical, and (4) Predicted Grade Average (PGA).

Class Rank, Converted is the variable derived from the student's rankings in their respective high school senior classes on the basis of grade-point average. The rankings were converted to a standard scale ranging from a low of twenty to a high of eighty, with a mean of fifty, a scale designed to coincide with the range of scores of the Scholastic

Aptitude Test (SAT). This variable is intended to be a measure of academic achievement.

The SAT Verbal variable is taken directly from students' scores on the Verbal section of the SAT, which was administered during the senior year of high school. The variable is intended to be a measure of basic verbal ability.

The SAT Mathematical variable is taken directly from students' scores on the Mathematical section of the SAT. The variable is intended to be a measure of basic mathematical reasoning ability.

The PGA variable is the Predicted Grade Average determined for each student by regression equation prior to his admission to Stetson University. The equation includes weighted amounts of the SAT Verbal score, the SAT Mathematical score, senior class rank, and English Composition scores.[19] The range of the scores is from 1.00 to 4.00. This variable is intended to be a measure of college academic achievement potential (see Table 6).

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[19]Four equations were used as follows:

(1) For men with English Composition scores,
PGA = .3316 Class Rank 4.0 SAT -V + .98 SAT-M
+ 6.0 CEEB English Composition - 1.37003.

(2) For men without English Composition scores,
PGA = .3305 Class Rank + 6.0 SAT -V + 1.12 SAT-M
- 1.44515.

(3) For women with English Composition scores,
PGA = .4615 Class Rank + .82 SAT -V + .45 SAT-M
+ 1.64 CEEB English Composition - 3.01929.

(4) For women without English Composition scores,
PGA = .4923 Class Rank + 1.92 SAT -V + .70 SAT-M
- 3.03620.

TABLE 6

NON-VISION VARIABLES, AND SOURCES FROM WHICH DERIVED

Variable number	Variable name	Source of variable
1	Reading Rate	Diagnostic Reading Pre-test, Rate in words-per-minute
2	Reading Story Comprehension	Diagnostic Reading Pre-test, Story comprehension raw score
3	Reading Paragraph Comprehension	Diagnostic Reading Pre-test, Paragraph comprehension raw score
16	Class Rank, Converted	Rank in senior class by grade-point average, converted to standard score
17	SAT Verbal	Scholastic Aptitude Test, Verbal section, raw score
18	SAT Mathematical	Scholastic Aptitude Test, Mathematical section, raw score
19	Predicted Grade Average	Predicted Grade Average, from regression equations utilizing several scores
21	Rate Change	Difference (gain-loss) between Pre-test and Post-test Reading Rate
22	Story Comprehension Change	Difference (gain-loss) between Pre-Test and Post-test Reading Story Comprehension
23	Paragraph Comprehension Change	Difference (gain-loss) between Pre-test and Post-test Reading Paragraph Comprehension

Statistical analysis.—The raw scores for each of the one hundred sixty-three subjects were converted to the appropriate variable scales and recorded on Data Coding Sheets prepared by the University of Florida Computing Center. Scores on the twenty-three variables were punched into standard eighty-column IBM cards.

A principal axis factor analysis with Varimax rotation was carried out, utilizing the IBM 709 Digital Computer and the RPAFAV program. The RPAFAV program is a three-step program involving (1) the computation of the correlation matrix, (2) principal axis factor analysis, and (3) normalized Varimax rotation.

Those subjects with uncorrected vision problems were then selected from the total group of one hundred sixty-three subjects. A sub-group of fifty-one subjects was found to have failed one or more of the vision tests presented by the Ortho-Rater. The scores of these fifty-one subjects on the twenty-three variables were factorized, again using the RPAFAV program.

Results from these analyses are contained in Chapter V.

CHAPTER V

RESULTS

The results of the statistical analysis of the data will be presented in this chapter. General results will be presented first, then specific results as these apply to the hypotheses. Six hypotheses were to be tested, and presentation of specific results will follow the order in which these hypotheses were listed in Chapter I.

General Results

Over-all factorization.--The first factor analysis was of the scores of all subjects (Group T) on the twenty-three variables. A complete correlation matrix of the twenty-three variables is presented in Appendix C.

Nine factors were precipitated in the principal axis factor analysis. Varimax rotation produced the Rotated Factor Matrix presented in Table 7. The communality for each variable, and the per cent of common variance for each factor are included in Table 7.

Visual disorder factorization.--The scores of a sub-group of fifty-one subjects who had uncorrected visual problems (Sub-group VP) were then factorized. A complete correlation matrix of the twenty-three variables is presented in Appendix C.

TABLE 7

ROTATED FACTOR MATRIX FROM OVERALL FACTORIZATION (GROUP T, N=163)

#	Variables Name	Rotated Factor Loadings 1	2	3	4	5	6	7	8	9	h^2
1	Reading Rate	-.04	.01	-.02	.02	.48	.01	.03	.01	.02	.23
2	Rdg. Story Comprehen.	.08	-.02	.04	.05	-.01	.07	.69	.19	.07	.54
3	Rdg. Parag. Comprehen.	.08	.06	.05	.06	.03	.13	.26	.69	.04	.58
4	Vert. Phoria Dev., Far	-.07	.52	.17	-.07	-.02	-.03	-.07	-.13	.05	.33
5	Vert. Phoria Dev., Near	.01	.31	.15	.04	-.10	-.10	.11	-.19	.02	.19
6	Lateral Phoria Dev., Far	.06	.50	-.02	-.01	.08	.00	-.12	.13	-.09	.29
7	Lateral Phoria Dev., Near	.00	.19	-.03	-.01	.05	.13	-.05	.14	.02	.08
8	Acuity Dev., Both, Far	.62	-.07	-.05	.21	.03	-.06	.13	-.03	.03	.45
9	Acuity Dev., Both, Near	.15	-.01	-.04	.63	-.03	.09	.14	-.05	.05	.45
10	Acuity Dev. Right, Far	.54	-.05	.39	.04	-.08	-.09	.03	.00	.04	.47
11	Acuity Dev. Right, Near	.05	.04	.64	.20	-.11	-.20	.08	-.01	.13	.52
12	Acuity Dev. Left, Far	.56	.07	.23	.12	.33	.14	.02	.12	-.09	.53
13	Acuity Dev. Left, Near	.17	-.06	.21	.60	.02	-.03	-.02	.11	-.02	.45
14	Acuity Imbalance, Far	.22	.08	.68	-.13	.20	.09	-.02	.05	-.14	.60
15	Acuity Imbalance, Near	.01	.10	.73	.07	.07	-.01	-.04	-.05	.00	.56
16	Class Rank	-.03	.00	-.05	.00	-.11	.85	.00	-.02	.07	.75
17	SAT Verbal	.01	.07	.11	.06	.04	.10	.02	.06	.68	.49
18	SAT Mathematical	.03	-.08	-.08	-.06	.05	.12	.00	-.06	.68	.51
19	PGA	.00	-.01	-.08	.13	-.05	.75	.10	.06	.42	.78
20	Hyperopia-Myopia	.67	.05	.02	.06	-.01	.00	.00	.05	.03	.46
21	Rate Change	-.10	-.01	-.07	.05	-.42	.11	.07	.00	-.03	.21
22	Story Comprehen. Change	-.05	.16	.01	-.06	.02	.03	-.61	-.09	.05	.41
23	Parag. Comprehen. Change	-.01	.04	.04	-.01	.01	.09	-.08	-.56	.02	.34
Sum of Squared Loadings		1.57	.72	1.75	.92	.62	1.47	1.02	.97	1.19	10.23
Per cent of common variance		15.36	7.08	17.08	9.03	6.06	14.37	9.93	9.53	11.61	100.0

Twelve factors were precipitated in the principal axis factor analysis. Varimax rotation produced the Rotated Factor Matrix presented in Table 8. The communality for each variable, and the per cent of common variance for each factor are also included in Table 8.

Specific Results

Hypothesis I.--The first hypothesis stated that specific factors which are components of vision are identifiable through factor analysis of scores on a battery of vision screening tests given to college students.

The over-all factor analysis elicited nine factors, four of which had highest loadings for those variables which were derived from vision tests. The rotated factor loadings for these four factors are presented in Table 9.

Hypothesis II.--The second hypothesis stated that there are positive relationships between the principal variables for vision factors, and changes in levels of reading skills as a result of a reading improvement course given to college students.

These relationships are approached from the point of view of the correlations between variables derived from vision tests and variables indicating changes in levels of reading skills. These correlations are presented in Table 10.

Hypothesis III.--The third hypothesis stated that there are positive relationships between levels of certain mental abilities and changes in levels of reading skills as a result of a reading improvement course given to college students.

TABLE 8

ROTATED FACTOR MATRIX FROM VISUAL PROBLEM FACTORIZATION (SUB-GROUP VP, N-51)

#	Variables Name	Rotated Factor Loadings 1	2	3	2	5
1	Reading Rate	-.09	.07	.09	.23	.09
2	Rdg. Story Comprehen.	.04	-.05	.00	.80	.17
3	Rdg. Parag. Comprehen.	.07	.10	.10	.30	.69
4	Vert. Phoria Dev., Far	-.18	-.18	-.04	.07	-.17
5	Vert. Phoria Dev., Near	-.11	.09	-.02	.08	-.09
6	Lateral Phoria Dev., Far	.04	.00	-.01	.00	.07
7	Lateral Phoria Dev., Near	-.17	-.02	.08	.04	.01
8	Acuity Dev. Both, Far	.62	.15	-.03	.24	.18
9	Acuity Dev. Both, Near	.02	.69	.00	.14	.07
10	Acuity Dev. Right, Far	.35	.10	-.13	.08	.02
11	Acuity Dev. Right, Near	-.19	.02	-.26	.10	.04
12	Acuity Dev. Left, Far	.67	.20	.03	.07	-.06
13	Acuity Dev. Left, Near	.17	.68	-.08	-.08	.07
14	Acuity Imbalance, Far	.23	.05	.06	.03	-.20
15	Acuity Imbalance, Near	-.06	.01	-.02	-.12	.02
16	Class Rank	-.07	-.09	.84	-.03	-.05
17	SAT Verbal	-.15	.12	.16	-.02	.11
18	SAT Mathematical	.08	-.10	.18	.01	-.03
19	PGA	-.11	.06	.59	.01	-.01
20	Hyperopia-Myopia	.73	-.01	-.08	.02	.19
21	Rate Change	-.14	.14	.06	.14	-.11
22	Story Comprehension Change	-.10	-.11	.05	-.63	-.05
23	Parag. Comprehension Change	-.16	-.07	.11	-.05	-.67
Sum of Squared Loadings		1.81	1.14	1.27	1.33	2.15
Per cent of Common Variance		12.13	7.65	8.52	8.93	14.41

TABLE 8 (continued)

Rotated Factor Loadings							h_2
6	7	8	9	10	11	12	
.09	-.08	-.08	.06	-.08	-.01	.59	.46
.11	.06	.06	.01	-.05	.02	.09	.70
.20	-.02	.04	.15	-.06	-.08	.21	.70
.27	.13	.31	.02	-.13	.43	.08	.50
.02	.01	.09	-.12	.07	.65	-.07	.48
.50	-.05	-.04	.00	-.02	.03	.03	.27
.10	-.01	-.15	-.22	-.34	-.34	-.17	.38
-.03	.05	-.16	-.17	.38	-.01	.00	.71
-.10	-.03	-.13	.05	.08	.08	.02	.55
-.01	-.05	.26	-.12	.63	.03	-.06	.65
-.15	-.02	.60	.03	.46	.17	-.05	.75
.18	.03	.34	.03	-.04	-.16	.27	.75
.12	-.06	.25	.07	-.01	-.03	-.06	.60
.16	-.10	.81	.03	.04	-.02	.13	.80
-.13	-.08	.81	.02	.11	.13	-.01	.73
-.02	.17	-.02	.09	-.10	-.04	.02	.78
.01	.12	.07	.72	-.04	-.09	-.01	.63
-.08	.80	-.12	.07	.01	.06	.05	.72
.00	.57	-.09	.38	-.11	-.08	.04	.86
.03	.02	-.04	-.08	.10	-.06	-.07	.60
.02	-.17	-.16	.07	-.08	-.01	-.49	.38
.06	.05	.08	.03	-.12	-.06	-.01	.46
-.01	.02	.11	-.02	-.07	.07	-.04	.52
.53	1.09	2.16	.83	.99	.84	.79	13.95
3.53	7.26	14.46	5.58	6.65	5.62	5.27	100.00

TABLE 9

ROTATED FACTOR LOADINGS FOR VISION FACTORS (GROUP T, N=163)

#	Variables Name	Rotated Factor Loadings 1	2	3	4
1	Reading Rate	-.04	.01	-.02	.02
2	Rdg. Story Comprehen.	.08	-.01	.04	.05
3	Rdg. Parag. Comprehen.	.08	.06	.05	.06
4	Vert. Phoria Dev., Far	-.07	.52	.17	-.07
5	Vert. Phoria Dev., Near	.01	.31	.15	.04
6	Lateral Phoria Dev., Far	.06	.50	-.02	-.01
7	Lateral Phoria Dev., Near	.00	.19	-.03	-.01
8	Acuity Dev. Both, Far	.62	-.07	-.05	.21
9	Acuity Dev. Both, Near	.15	-.01	-.04	.63
10	Acuity Dev. Right, Far	.54	-.05	.39	.04
11	Acuity Dev. Right, Near	.05	.04	.64	.20
12	Acuity Dev. Left, Far	.56	.07	.23	.12
13	Acuity Dev. Left, Near	.17	-.06	.21	.60
14	Acuity Imbalance, Far	.22	.08	.68	-.13
15	Acuity Imbalance, Near	.01	.10	.73	.07
16	Class Rank	-.03	.00	-.05	.00
17	SAT Verbal	.01	.07	.11	.06
18	SAT Mathematical	.03	-.08	-.08	-.06
19	PGA	.00	-.01	-.08	.13
20	Hyperopia-Myopia	.67	.05	.02	.06
21	Rate Change	-.10	-.01	-.07	.05
22	Story Comprehension Change	-.05	.16	.01	-.06
23	Parag. Comprehension Change	-.01	.04	.04	-.01

TABLE 10

CORRELATIONS BETWEEN VISION VARIABLES AND VARIABLES INDICATING READING SKILLS CHANGE (GROUP T, N = 163)

Vision Variables		Reading Skills Change		
#	Name	#21 Rate Change	#22 Story Comp. Change	#23 Para. Comp. Change
4	Vert. Phoria Dev., Far	-.07	.19	.12
6	Lat. Phoria Dev., Far	.00	.15	-.07
8	Acuity Dev. Both, Far	-.06	-.14	-.02
10	Acuity Dev. Right, Far	-.10	-.06	-.01
12	Acuity Dev. Left, Far	-.14	-.04	-.03
14	Acuity Imbalance, Far	-.09	.04	.04
20	Hyperopia-Myopia	-.12	-.01	-.02
5	Vert. Phoria Dev., Near	.05	-.02	.09
7	Lat. Phoria Dev., Near	.00	.09	.05
9	Acuity Dev. Both, Near	.06	-.11	.02
11	Acuity Dev. Right, Near	-.09	-.05	.01
13	Acuity Dev. Left, Near	.02	-.06	-.06
15	Acuity Imbalance, Near	-.07	.05	.05

These relationships are shown in the correlations between those variables derived from scores on the Scholastic Achievement Test and those variables indicating changes in levels of reading skills. Table 11 presents these correlations.

Hypothesis IV.--The fourth hypothesis stated that there are positive relationships between previous academic achievement and changes in levels of reading skills as a result of a reading improvement course given to college students.

These relationships are shown through the correlations between the variables indicating previous academic achievement (Class Rank, Converted and Predicted Grade Average) and those variables which indicate changes in levels of reading skills. Table 12 presents these correlations.

Hypothesis V.--The fifth hypothesis stated that there are positive relationships between initial levels of reading skills and changes in levels of reading skills as a result of a reading improvement course given to college students.

These relationships are indicated by the correlations between variables derived from the reading pre-test and variables derived from the reading post-test. Table 13 presents these correlations.

Hypothesis VI.--The sixth hypothesis stated that the nature of vision factors, and their relationships with changes in reading skills, differ between subjects with uncorrected vision problems and the total group of subjects.

The results presented under Hypothesis I indicated that four factors precipitated from the scores of all subjects on the twenty-three variables had highest loadings on variables derived from vision tests.

TABLE 11

CORRELATIONS BETWEEN CERTAIN MENTAL ABILITIES VARIABLES AND VARIABLES INDICATING READING SKILLS CHANGE (GROUP T, N = 163)

Mental Abilities Variables #	Name	Reading Skills Change Variables #21 Reading Rate Change	#22 Story Comp. Change	#23 Paragraph Comp. Change
17	SAT Verbal	.02	.05	.04
18	SAT Mathematical	-.02	.03	.01

TABLE 12

CORRELATIONS BETWEEN VARIABLES INDICATING PREVIOUS ACADEMIC ACHIEVEMENT AND VARIABLES INDICATING READING SKILLS CHANGE (GROUP T, N = 163)

Academic Achievement Variable #	Name	Reading Skills Change Variables #21 Reading Rate Change	#22 Story Comp. Change	#23 Paragraph Comp. Change
16	Class Rank, Converted	.13	.03	.09
19	PGA	.09	-.03	.07

TABLE 13

CORRELATIONS BETWEEN VARIABLES INDICATING PREVIOUS LEVELS OF READING SKILLS AND VARIABLES INDICATING READING SKILLS CHANGE (GROUP T, N = 163)

Previous Reading Skills Variables #	Name	Reading Skills Change Variables #21 Reading Rate Change	#22 Story Comp. Change	#23 Paragraph Comp. Change
1	Reading Rate	-.35	-.05	.01
2	Reading Story Comprehension	.04	-.63	-.07
3	Reading Paragraph Comprehension	.01	-.18	-.61

Of the twelve factors precipitated from scores of the visual disorder sub-group, six factors had highest loadings on variables derived from vision tests. This comparison of the nature of vision factors between subjects with uncorrected vision problems and the total group of subjects is presented in Table 14.

The relationships between vision factors and change in reading skills for the total group of subjects were presented under Hypothesis II by means of correlations between selected variables (see Table 10). In order to compare the changes in reading skills between the total group of subjects and those subjects with uncorrected vision problems, the correlations for both groups are presented in Table 15.

Only the results of the statistical analysis have been presented in this chapter. An analysis of the results, including discussion and implication, will be presented in Chapter VI.

TABLE 14

COMPARISON OF VISION FACTORS BETWEEN ALL SUBJECTS AND SUBJECTS WITH UNCORRECTED VISION PROBLEMS

#	Variables Name	Rotated Factor Loadings Group T 1*	4	3	2
1	Reading Rate	-.04	.02	-.02	.01
2	Reading Story Comprehension	.08	.05	.04	-.01
3	Reading Para. Comprehension	.08	.06	.05	.06
4	Vertical Phoria Dev., Far	-.07	-.07	.17	.52
5	Vertical Phoria Dev., Near	.01	.04	.15	.31
6	Lateral Phoria Dev., Far	.06	-.01	-.02	.50
7	Lateral Phoria Dev., Near	.00	-.01	-.03	.19
8	Acuity Deviation Both, Far	.62	.21	-.05	-.07
9	Acuity Deviation Both, Near	.15	.63	-.04	-.01
10	Acuity Deviation Right, Far	.54	.04	.39	-.05
11	Acuity Deviation Right, Near	.05	.20	.64	.04
12	Acuity Deviation Left, Far	.56	.12	.23	.07
13	Acuity Deviation Left, Near	.17	.60	.21	-.06
14	Acuity Imbalance, Far	.22	-.13	.68	.08
15	Acuity Imbalance, Near	.01	.07	.73	.10
16	Class Rank	-.03	.00	-.05	.00
17	SAT Verbal	.01	.06	.11	.07
18	SAT Mathematical	.03	-.06	-.08	-.08
19	PGA	.00	.13	-.08	-.01
20	Hyperopia-Myopia	.67	.06	.02	.05
21	Reading Rate Change	-.10	.05	-.07	-.01
22	Story Comprehension Change	-.05	-.06	.01	.16
23	Paragraph. Comp. Change	-.01	-.01	.04	.04

*Numbers indicate order in which the factors appear in each rotated factor matrix.

TABLE 14 (continued)

Rotated Factor Loadings Sub-group VP					
1	10	2	8	11	6
-.09	-.08	.07	-.08	-.01	.09
.04	-.05	-.05	.06	.02	.11
.07	-.06	.10	.04	-.08	.20
-.18	-.13	-.18	.31	.43	.27
-.11	.07	.09	.09	.65	.02
.04	-.02	.00	-.04	.03	.50
-.17	-.34	-.02	-.15	-.34	.10
.62	.38	.15	.16	-.01	-.03
.02	.08	.69	-.13	.08	-.10
.35	.63	.10	.26	.03	-.01
-.19	.46	.02	.60	.17	-.15
.67	-.04	.20	.34	-.16	.18
.17	-.01	.68	.25	-.03	.12
.23	.04	.05	.81	-.02	.16
-.06	.11	.01	.81	.13	-.13
-.07	-.10	-.09	-.02	-.04	-.02
-.15	-.04	.12	.07	-.09	.01
.08	.01	-.10	-.12	.06	-.08
-.11	-.11	.06	-.09	-.08	.00
.73	.10	-.01	-.04	-.06	.03
-.14	-.08	.14	.16	-.01	.02
-.10	-.12	-.11	.08	-.06	.06
-.16	-.07	-.07	.11	.07	-.01

TABLE 15

COMPARISON OF CORRELATIONS BETWEEN VISION VARIABLES AND VARIABLES INDICATING READING SKILLS CHANGE FOR TOTAL GROUP (N=163) AND VISION PROBLEMS SUB-GROUP (N=51)

#	Vision Variables Name	Reading Skills Change Variables					
		#21 Rate Change		#22 Story Comp. Change		#23 Paragraph Comp. Change	
		Group T	Sub-group VP	Group T	Sub-group VP	Group T	Sub-group VP
4	Vert. Phoria Dev., Far	-.07	-.09	.19	.07	.12	.27
6	Lat. Phoria Dev., Far	.00	.05	.15	.07	-.07	-.06
8	Acuity Dev. Both, Far	-.06	-.07	-.14	-.40	-.02	-.32
10	Acuity Dev. Right, Far	-.10	-.10	-.06	-.16	-.01	-.08
12	Acuity Dev. Left, Far	-.14	-.26	-.04	-.09	-.03	-.03
14	Acuity Imbalance, Far	-.09	-.18	.04	.05	.04	.24
20	Hyperopia-Myopia	-.12	-.10	-.01	-.06	-.02	-.20
5	Vert. Phoria Dev., Near	.05	.08	-.02	-.10	.09	.11
7	Lateral Phoria Dev., Near	.00	.21	.09	.09	.05	.05
9	Acuity Dev. Both, Near	.06	.15	-.11	-.21	.02	-.10
11	Acuity Dev. Right, Near	-.09	-.12	-.05	-.10	.01	.01
13	Acuity Dev. Left, Near	.02	.05	-.06	-.02	-.06	-.13
15	Acuity Imbalance, Near	-.07	-.11	.05	.14	.05	.06

CHAPTER VI

DISCUSSION

The purpose of the present study was to determine the relationships between vision and changes in reading skills as a result of a reading improvement course, and the effect of uncorrected vision problems upon these relationships. Six hypotheses were to be tested; therefore a specific discussion relates the findings to these hypotheses, following the order of their presentation in Chapter I. A general discussion follows which considers other aspects of the study not specifically related to the hypotheses.

Discussion of Hypotheses

Hypothesis I

The first hypothesis stated that specific factors which are components of vision are identifiable through factor analysis of scores on a battery of vision screening tests given to college students.

Factor analysis of the scores of all subjects on the twenty-three variables elicited nine factors, four of which had highest loadings for those variables derived from vision tests. These four factors are discussed in an order which lends itself to easy interpretation. The interpretations are for the most part based upon principal variables,

that is, variables with rotated factor loadings of plus or minus .50 or greater. Factors are named on the basis of those test scores which would contribute to high factor loadings when considering the direction of the rotated factor loadings.

Factor T-1:[1] Acuity Deviation, Far.—The rotated factor loadings and intercorrelations for the principal variables for this factor are as follows:

No.	Variable	Loading	r		
			#10	#12	#20
8	Acuity Deviation Both, Far	.62	.40	.40	.38
10	Acuity Deviation Right, Far	.54		.25	.40
12	Acuity Deviation Left, Far	.56			.44
20	Hyperopia-Myopia	.67			

The principal variables for this factor are Hyperopia-Myopia and three acuity variables at far-point. Apparently the method of deriving the Hyperopia-Myopia variable served to emphasize the importance of far-point acuity deviations in measuring hyperopia and myopia.

Because the principal loadings were positive on all acuity variables measured by acuity deviations at far-point, this factor has been called Acuity Deviation, Far. It accounts for 15.35 per cent of the common variance extracted from the matrix by all nine factors. By comparison with the findings of Cook[2] it is probable that this factor would be related to two factors he named Retinal Resolution and Lens Accommodation. Robinson and Huelsman described their first factor simply as Acuity, since

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[1] This designation of factors indicates the group of subjects involved and the order of appearance in the rotated factor matrix.

[2] Cook, loc. cit.

in their study the factor had loadings on both near-point and far-point acuity tests.[3] In both named studies, a second factor differentiated by sign between near-point and far-point acuity tests.

Factor T-4: Acuity Deviation, Near.—The rotated factor loadings and intercorrelations for the principal variables for Factor T-4 are as follows:

No.	Variable	Loading	r	
			#13	#11
9	Acuity Deviation Both, Near	.63	.41	.14
13	Acuity Deviation Left, Near	.60		.24
(11	Acuity Deviation Right, Near	.20)		

The principal variables for this factor are derived from positive loadings on tests of binocular acuity deviation at near-point and of left eye acuity deviation at near-point. The factor is therefore called Acuity Deviation, Near. It is the companion factor to Factor T-1.

The presence of both factors points out the importance of measurements of acuity at both near-point and far-point in a vision screening battery. Although a weaker factor than its companion, this factor accounts for 9.03 per cent of the common variance extracted from the matrix.

As noted above, studies by Cook and by Robinson and Huelsman described acuity factors, one of which differentiated between vision tests at near-point and at far-point. It is believed that Factors T-1

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[3]Helen M. Robinson and Charles B. Huelsman, Jr., "Visual Efficiency and Progress in Learning to Read," in Helen M. Robinson (ed.), Clinical Studies in Reading II (Chicago: University of Chicago Press, 1953), p. 58.

and T-4 specifically identify acuity as an important area of vision, and just as specifically point out the importance of acuity measures at both distances.

It should be noted that both acuity factors have principal variables derived from tests of binocular acuity. Also, the relatively low intercorrelations among binocular acuity variables and monocular acuity variables indicate the necessity for considering these as separate contributors to the acuity factors. Too, the importance of binocular vision for reading has been emphasized by researchers for over thirty years. These facts serve to emphasize the need for including tests of binocular acuity in a vision screening battery.

Factor T-3: Acuity Imbalance.--The rotated factor loadings and intercorrelations for the principal variables for this factor are as follows:

No.	Variable	Loading	r	
			#14	#11
15	Acuity Difference, Near	.73	.53	.50
14	Acuity Difference, Far	.68		.32
11	Acuity Deviation Right, Near	.64		

The principal variables for this factor are derived from positive loadings on measures of imbalance in acuity of the two eyes, one at near-point and one at far-point, and the measure of right eye acuity deviation at near-point. The factor is called Acuity Imbalance. Acuity Imbalance is the strongest factor precipitated, in that it accounts for 17.08 per cent of the total variance extracted from the matrix.

Kelly included measures of Acuity Imbalance in his study, but felt the narrow range measured by the variable contributed to its unreliability. Despite this, he suggested imbalance in acuity "may be an important visual function."[4] Spache and Tillman found that acuity difference between the two eyes at near-point differentiated between retarded and non-retarded readers.[5] The findings of these authors are definitely supported by the presence of Factor T-3, and suggests the value of considering Acuity Imbalance in clinical studies.

Further evidence of the importance of unequal acuity of the separate eyes is found in the contributions of these variables to Factor T-4 as well as to Factor T-3. Right eye acuity deviations contribute much less to the factor Acuity Deviation, Near and are definitely associated with Acuity Imbalance at both distances. This supports the findings of Spache and Tillman, who suggested retarded readers might prefer the right eye. A reason for such preference might now be hypothesized.

Cook did not find evidence for the importance of acuity differences between the two eyes; indeed the study did not consider such differences. However, Robinson and Huelsman describe a factor which "differentiates among performances by right eye, both eyes, and left eye."[6] The data presented by these authors are reproduced in Table 16,

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[4]Charles R. Kelly, Visual Screening and Child Development (Raleigh, North Carolina: North Carolina State Teachers College, 1957), pp. 4, 5, 24.

[5]George D. Spache and Chester E. Tillman, "A Comparison of the Visual Profiles of Retarded and Non-retarded Readers," Journal of Developmental Reading, Vol. 5 (Winter, 1962), pp. 101-109.

[6]Robinson and Huelsman, op. cit., p. 58.

and reveal that this conclusion is true for the Ortho-Rater tests only for Grade VII. Acuity Imbalance may, then, be a functional development related to educational misuse of the vision mechanism.

TABLE 16

ACUITY TEST FACTOR LOADINGS REPORTED BY ROBINSON AND HUELSMAN ON FACTOR C

Ortho-Rater Test	Grade IV	Grade VII
Binocular acuity, far	17	37
Right eye acuity, far	12	34
Left eye acuity, far	13	-10
Binocular acuity, near	38	28
Right eye acuity, near	15	39
Left eye acuity, near	11	-11

Factor T-2: Phoria, Far.--The rotated factor loadings and correlations for this factor are as follows:

No.	Variable	Loading	r		
			#6	#5	#7
4	Vertical Phoria Deviation, Far	.52	.27	.23	.07
6	Lateral Phoria Deviation, Far	.49		.10	.12
(5	Lateral Phoria Deviation, Near	.31)			.07
(7	Vertical Phoria Deviation, Near	.19)			

The principal variables for this relatively weak factor are derived from positive loadings on far-point measures of phoria. The Phoria, Far factor accounts for only 7.08 per cent of the common variance extracted from the correlation matrix. Although far-point measures of vertical and lateral phoria are the major contributors to this factor, the intercorrelations

indicate near-point tests to be measuring unrelated, if less important, entities.

One must conclude that, in the total group, far-point measures of phoria are more important than those at near-point, while at reading distance lateral phoria is more important than vertical phoria. The weakness of this factor probably stems from (1) the narrow range of the vertical phoria measure, and (2) the recognized unreliability of lateral phoria measures, and is evidenced by the low communalities of the primary variables.

Thus, in a battery of vision screening tests, the clinician might expect to include at least far phoria measures, while recognizing the separate contributions of near phoria tests when time is available to include them.

Cook reported four factors derived from measures of phoria: (1) lateral phoria, measured best by commercial screening devices, (2) near lateral phoria, as measured by screening tests, (3) hyperphoria (vertical phoria), and (4) a factor related to change in vertical phoria after rest.[7] The phoria factor in the present study is general, and the first three factors described by Cook.

Perhaps it should be recalled that Robinson and Huelsman made no attempt to elicit and name phoria factors, assumedly because of the curvilinear nature of these measures. It is hoped that the use of deviation scores in the present study has in part eliminated the problem, and allowed a clear picture of the contribution of phoria variables to be shown in a single general factor.

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[7] Cook, loc. cit.

Hypothesis I seems adequately supported by the precipitation of four factors which identify relatively independent components of vision. From thirteen variables derived from ten vision tests, three acuity factors and one phoria factor have been identified.

Hypothesis II

The second hypothesis stated that there are positive relationships between vision factors, and changes in levels of reading skills as a result of a reading improvement course given to college students.

The correlations between these variables have been presented in Table 10. In general, Hypothesis II was not supported by the data, since all correlations were very low. While one might observe general trends such as (1) negative relationships between acuity deviations and Rate Change, (2) negative relationships between acuity deviations and Story Comprehension Change, and (3) positive relationships between phoria variables and Story Comprehension Change, these are obviously only minor trends and not supported by significant correlations.

Hypothesis III

The third hypothesis stated that there are positive relationships between levels of certain mental abilities and change in levels of reading skills as a result of a reading improvement course given to college students.

The correlations between the mental abilities measured by the Scholastic Aptitude Test and change in levels of reading skills are as follows:

	Reading Rate Change	Story Comp. Change	Paragraph Comp. Change
Verbal Reasoning	.02	.05	.04
Quantitative Reasoning	-.02	.03	.01

Hypothesis III was not supported by the data.

Change in levels of reading skills apparently is independent of both verbal ability and quantitative ability at the college freshman level. This might well be because at this educational level the measured abilities are relatively homogeneous. A second consideration is that all these students probably have verbal and quantitative ability beyond a necessary minimum for success and changes in levels of reading skills are dependent upon other variables.

Hypothesis IV

The fourth hypothesis stated that there are positive relationships between previous academic achievement and change in levels of reading skills as a result of a reading improvement course given to college students.

The correlations between the variables indicating prior academic achievement (Class Rank, Converted) and predicted academic achievement (Predicted Grade Average), and variables indicating reading skills changes are shown below:

	Reading Rate Change	Story Comp. Change	Paragraph Comp. Change
Class Rank, Converted	.13	.03	.09
Predicted Grade Average	.09	-.03	.07

Hypothesis IV was not supported by the data.

The consistent low correlations indicate that changes in reading skills are also independent of previous academic achievement, at least at the college freshman level. It was expected that a paragraph comprehension measure, which requires a study-type approach, would correlate positively with academic achievement. With these subjects, however, there was no relationship between the two.

As anticipated, Predicted Grade Average was seen to correlate highly (r = .73) with prior academic achievement.[8] For this reason its relationship with changes in reading skills was noted. Changes in reading skills were also found to be independent of the PGA variable, as they were of the components entering into the equations.

Hypothesis V

The fifth hypothesis stated that there are positive relationships between initial levels of reading skills and changes in levels of reading skills as a result of a reading improvement course given to college students.

The correlations between initial reading skills and changes attributed to the reading improvement course are shown below:

	Rate Change	Story Comp. Change	Paragraph Comp. Change
Reading Rate	-.35	-.05	.01
Reading Story Comp.	.04	-.63	-.07
Reading Paragraph Comp.	.01	-.18	-.61

[8]The four regression equations used to predict grade point averages included Class Rank, Converted, and two equations included English Composition scores, SAT Verbal and SAT Quantitative scores were also included.

This hypothesis is refuted by the data. The only significant correlations are negative rather than positive, indicating that students initially lowest in a reading skill would make the greatest change in that skill. This emphasis is necessary since change in any single reading skill is apparently independent of changes in other reading skills.

Support for the independence of each reading skill is derived from the fact that each of three of the nine factors elicited has highest loadings on one reading skill and its related change. The rotated loadings for these factors are listed below:

	Factor T-5 Reading Rate	Factor T-7 Reading Story Comp.	Factor T-8 Reading Paragraph Change
Reading Rate	.48		
Rate Change	-.42		
Reading Story Comprehension		.69	
Story Comprehension Change		-.61	
Reading Paragraph Comp.			.69
Paragraph Comp. Change			-.56

On the basis of these data the clinician might expect students to make gains in any one reading skill without greatly affecting the level of performance on other reading skills.

As Spache has suggested, the clinician might also expect the law of diminishing returns to operate in his instruction of students in reading.[9] This conclusion is supported by the opposing signs for factor loadings on the reading skills factors, and by the negative correlations

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[9]George D. Spache, "Clinical Work with College Students," in College-Adult Reading Instruction, IRA Perspectives in Reading I (Newark, Delaware, 1964), p. 138.

between the reading skills variables. Thus the student initially highest in a reading skill would be expected to gain least in that skill. One must, however, apply this finding with care to the skill Reading Rate, since the correlation between this variable and Rate Change is relatively low. The clinician might expect this low correlation since he is aware of the many influences upon reading rate.

Hypothesis VI

The sixth hypothesis stated that (1) the nature of vision factors, and (2) their relationships with changes in reading skills, differ between the total group of subjects, and subjects with uncorrected vision problems.

The discussion under Hypothesis I pointed out the four vision factors which were precipitated from scores of the total group of one hundred sixty-three subjects on twenty-three variables. When scores for Sub-group VP were factorized, a total of six vision factors was precipitated. In Table 17 it is possible to see the major differences in vision factors between these two groups.

For the vision problem sub-group, right eye acuity at far-point becomes a more important measure, as seen in the presence of a specific factor for this variable. An indication of the reason for this importance is seen in the negative correlations (Appendix C) right eye acuity at far-point had with initial reading rate, all reading skills changes, academic achievement, and mental abilities. The tendency toward negative relationships was present in the total group, but it was

TABLE 17

COMPARISON OF PRINCIPAL FACTOR LOADINGS OF VISION FACTORS
BETWEEN GROUP T (N=163) AND SUB-GROUP VP (N-51)

#	Variables Name	Group T Factor	Loading	Sub-group VP Factor	Loading
		Acuity Deviation, Far		Acuity Deviation, Far	
20	Hyperopia-Myopia		.67		.73
8	Acuity Dev. Both, Far		.62		.62
12	Acuity Dev. Left, Far		.56		.67
10	Acuity Dev. Right, Far		.54		
				Right Acuity Deviation, Far	
10	Acuity Dev. Right, Far				.63
		Acuity Deviation, Near		Acuity Deviation, Near	
9	Acuity Dev. Both, Near		.63		.69
13	Acuity Dev. Left, Near		.60		.68
		Acuity Imbalance		Acuity Imbalance	
15	Acuity Difference, Near		.73		.81
14	Acuity Difference, Far		.68		.81
11	Acuity Dev. Right, Near		.64		.60
		Phoria, Far		Lateral Phoria, Far	
4	Vert. Phoria Dev., Far		.52		.50
6	Lateral Phoria Dev., Far		.49		
				Vertical Phoria	
5	Vert. Phoria Dev., Near				.65
4	Vert. Phoria Dev., Far				.43

significantly higher ($p = .05$)[10] with subjects who had uncorrected vision problems. This finding is related to that made by Spache and Tillman who concluded that retarded readers were poorer in left-eye acuity.[11]

A third difference in the nature of vision factors between the total group and subjects with uncorrected vision problems is in the area of phoria. For the total group, Phoria, Far was the only factor with high loadings on phoria variables. However, for subjects with uncorrected vision problems, vertical phoria emerged as a valuable measure. This was evidenced by the elicitation of the Vertical Phoria factor. There was higher loading on vertical phoria at near-point, but vertical phoria at far-point was sufficiently high to be considered as contributing. There was also a substantial correlation ($r = .38$, $p = .01$) between the near-point and far-point measures.

Slight changes in the correlations between vertical and lateral phoria variables between the two groups indicated minor trends. These are shown in the correlations listed below:

		#4	#5	#6	#7	
#4	Vertical Phoria, Dev., Far		.38	.16	-.11	Sub-group VP
#5	Vertical Phoria, Dev., Near	.23		.01	-.29	
#6	Lateral Phoria, Dev., Far	.27	.10		.04	
#7	Lateral Phoria, Dev., Near	.07	-.07	.12		
		Group T				

There was an increasing trend toward negative relationships between vertical and lateral phoria for subjects with uncorrected vision problems.

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[10] Chi square, corrected for continuity, equals 5.2.

[11] Spache and Tillman, op. cit., p. 109.

Vertical phoria at the two distances tended to become more highly correlated; lateral phoria at the two distances remained uncorrelated.

These facts indicate that vertical phoria measures at both distances, and lateral phoria measures at both distances are valuable for complete screening of vision. If only one vertical phoria measure is to be included, this should be at near-point, rather than at far-point as in one commercial instrument.[12]

The Acuity Deviation, Near factor remained relatively unchanged between the two groups, even to the amount of variance accounted for from the correlation matrices. Acuity Imbalance also remained the strongest factor in terms of the amount of variance accounted for. The relationship between acuity imbalance and right eye acuity at near-point continued as an indication of the importance of difference in acuity between the two eyes.

General Discussion

There were several important aspects of the present study which were not considered in the discussion related specifically to the hypotheses. One of these was the relation which vision has to prior levels of reading skills.

For the total group of subjects, there were no significant relationships between previously attained reading skills and any vision variable. This was also true for the Vision Problem sub-group.

---

[12]The Keystone Telebinocular measures vertical phoria only at far-point.

As has been previously mentioned, for the total group of subjects there were no significant correlations between vision variables and changes in levels of reading skills as a result of the reading improvement course. For subjects with uncorrected vision problems, however, there were several significant correlations.

Paragraph Comprehension Change was significantly related to vertical phoria at far-point ($r = .27$, $p = .05$). But probably the most meaningful correlations are negative between binocular acuity deviations at far-point and both measures of reading comprehension. These correlations indicate that for subjects of the Vision Problem sub-group deviations in binocular acuity at far-point interfere with change in Story Comprehension ($r = -.40$, $p = .01$) and with Paragraph Comprehension change ($r = -.32$, $p = .02$).

Although the differences were not significant, students in Subgroup VP were initially higher in all reading skills, but made less gain than the total group in rate of reading, while gaining more in story comprehension. A plausible explanation is that these students must expend more effort controlling defective vision, and reach a peak rate sooner than the general student population. Slower rate enables more emphasis upon comprehension, which is the mode of compensation enabling the student with uncorrected vision problems to continue in higher education.

A second difference in the two groups of subjects was the relation which vision has to academic achievement. The correlations

between these two types of variables are listed in Table 18. For the total group of subjects there was practically no indicated relationships between variables measuring academic achievement and vision variables. Possible consideration should be given to (1) the small positive relationship between deviations in binocular acuity at near-point and Predicted Grade Average, and (2) to the small negative relationship between Class Rank and right eye deviations at near-point.

Students with uncorrected vision problems generally tended to indicate more and higher negative correlations ($p = .05$)[13] between vision and measures of academic achievement. Particularly important were the negative correlations between right eye acuity deviations and academic achievement. This emphasis upon right eye acuity was maintained throughout the study by various measures.

The relationships between the measured mental abilities and vision should also be considered. Correlations between these two types of variables are shown in Table 19. Again, the correlations were not sufficiently high to be significant. However, there was a trend (not significant)[14] toward negative correlations between visual deviations and measured mental abilities. The subjects with uncorrected vision problems indicated higher negative correlations between the two types of variables. It was especially noticeable that the highest negative correlations were between verbal ability and (1) the variables indicating deviations in binocular acuity and in right eye acuity at far-point, and (2) lateral phoria deviations at reading distance.

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[13]Chi square, corrected for continuity, equals 5.04.

[14]Chi square, corrected, equals 2.56.

TABLE 18

CORRELATIONS BETWEEN VISION VARIABLES AND VARIABLES MEASURING ACADEMIC ACHIEVEMENT

#	Variables Name	#16 Class Rank Group T	#16 Class Rank Sub-gp. VP	#19 PGA Group T	#19 PGA Sub-gp. VP
4	Vert. Phoria Dev., Far	-.04	-.02	-.03	.04
5	Vert. Phoria Dev., Near	-.04	-.03	-.08	-.12
6	Lateral Phoria Dev., Far	-.03	-.04	-.05	-.03
7	Lateral Phoria Dev., Near	.11	.11	.06	.06
8	Acuity Dev. Both, Far	-.06	-.14	.01	-.11
9	Acuity Dev. Both, Near	.09	-.07	.19	.05
10	Acuity Dev. Right, Far	-.07	-.22	-.07	-.29
11	Acuity Dev. Right, Near	-.18	-.30	-.08	-.25
12	Acuity Dev. Left, Far	.01	-.04	.06	-.02
13	Acuity Dev. Left, Near	-.08	-.18	.01	-.04
14	Acuity Imbalance, Far	-.01	.04	-.08	-.12
15	Acuity Imbalance, Near	-.04	-.03	-.08	-.14
20	Hyperopia-Myopia	-.01	-.13	.01	-.17

TABLE 19

CORRELATIONS BETWEEN VISION VARIABLES AND MEASURED MENTAL ABILITIES

#	Variables Name	#17 Verbal Group T	#17 Verbal Sub-gp. VP	#18 Quantitative Group T	#18 Quantitative Sub-gp. VP
4	Vert. Phoria Dev., Far	.04	.00	-.01	.09
5	Vert. Phoria Dev., Near	.03	-.18	.04	.01
6	Lateral Phoria Dev., Far	-.04	-.01	-.11	-.08
7	Lateral Phoria Dev., Near	.08	-.19	-.01	-.03
8	Acuity Dev. Both, Far	.02	-.25	.04	.09
9	Acuity Dev. Both, Near	.04	.09	.01	-.05
10	Acuity Dev. Right, Far	.06	-.19	.00	-.08
11	Acuity Dev. Right, Near	.13	.04	-.04	-.12
12	Acuity Dev. Left, Far	.02	.00	-.02	.04
13	Acuity Dev. Left, Near	.07	.13	-.08	-.17
14	Acuity Imbalance, Far	.02	.02	-.11	-.17
15	Acuity Imbalance, Near	.09	.03	-.05	-.16
20	Hyperopia-Myopia	.05	-.15	.01	.04

When scores for all subjects were factorized, a single mental ability factor was precipitated which had highest factor loadings on measures of both verbal and quantitative ability. Factorization of Sub-group VP scores precipitated two factors, one related to Verbal ability and the second related to quantitative ability (see below). The correlations under the two conditions (also listed below) indicate that the verbal and quantitative abilities are significantly less related in the sub-group with vision problems. One possible explanation for this difference lies in the fact that there were almost twice as many female as male subjects with uncorrected vision problems. A second possible explanation is in the compensation technique utilized by subjects with uncorrected vision problems. Quantitative reasoning does not require rapid reading, but verbal reasoning requires a wide reading experience for the development of vocabulary and method. These subjects may functionally separate the two types of reasoning because of emphasis upon the separate approach required of them.

	Variable	Group T		Sub-group VP	
		Loading	r	Loading	r
#17	SAT Verbal	.68	.48	.72*	.12
#18	SAT Quantitative	.68		.80**	

*Factor VP-9
**Factor VP-7

There were the expected correlations between the measured mental abilities and the Predicted Grade Average variable (see Appendix C). These high correlations are of course due to the inclusion of the mental ability scores in the regression equations used for prediction of grade averages.

CHAPTER VII

SUMMARY, CONCLUSIONS, AND CLINICAL CONSIDERATIONS

Summary

The purpose of the present study was to determine the relationships between vision and change in the levels of reading skills as a result of a reading improvement course, and the effect of uncorrected vision problems upon these relationships. Six hypotheses were to be tested by factor analysis of the scores of selected subjects on a series of tests.

In order to accomplish this purpose, one hundred eighty subjects were selected from the entering freshman class at Stetson University. The subjects were the poorest readers in the class as selected by the Cooperative English Test, Reading Comprehension Total Score. All subjects were given individual vision screening using a battery of twelve vision tests presented by the Ortho-Rater.

These subjects were also given a carefully prepared reading improvement course emphasizing (1) increase in rate of reading by machine training, and (2) flexibility in reading, utilizing various methods according to purpose. The Diagnostic Reading Test, Form A was used as a reading pre-test to measure the initial level of reading skills. Form D of the DRT was used as a reading post-test to measure changes in levels of reading skills attributable to the reading improvement course.

A total of one hundred sixty-three subjects completed the reading improvement course and all tests. Scores from ten vision tests were translated to ten deviation scales, and three derived scales. A total of thirteen vision variables was thus available. The Diagnostic Reading Test, Form A raw scores were used as a measure of initial reading skills. Differences between raw scores on the DRT Form D and the DRT Form A were used as reading change scores which were attributable to a Reading Improvement Course. From these tests six reading variables were thus available.

The Office of Admissions at Stetson University made available the subjects' scores on the Verbal and Mathematical sections of the Scholastic Aptitude Test, the subjects' high school class rank, and predicted grade averages. Scaled scores on the SAT Verbal and Mathematical sections were used as two variables measuring mental abilities. Class ranks were converted to a standard scale, and used as a measure of academic achievement. Predicted grade averages were used as a multi-test indication of potential academic achievement.

Thus the scores of one hundred sixty-three subjects on twenty-three variables were factorized utilizing the RPAFAV program for the IBM 709 Computer. The three steps in the program produced the correlation matrix, the principal axis factor analysis, and the Varimax rotation. Nine factors were precipitated in this factorization.

A total of fifty-one subjects was selected who failed one or more of the vision screening tests administered. Scores by these

subjects on the twenty-three variables were factorized utilizing the same computer program. Twelve factors were precipitated in this factorization.

The results from the two factorizations were presented in detail in Chapter V and in Appendix C. General results were presented, and specific results given as these related to the six hypotheses. In Chapter VI a detailed discussion of these findings was given as they related to the hypotheses, and to general questions raised in the survey of the literature.

Conclusions

Vision tests.--One of the preliminary steps to comparison of vision and reading is obtaining adequate, easily available vision tests. Factorization of the scores of all subjects on a commercially available screening battery precipitated four vision factors, while factorization of the scores of the vision problem sub-group precipitated six vision factors.

Analysis of these data led to the following conclusions regarding vision screening:

(1) There are relatively independent measures of vision function for subjects at the college freshman level;

(2) Acuity at far-point and acuity at near-point are sufficiently independent to be measured separately;

(3) Tests of binocular acuity are important measures to be included in a vision screening battery;

(4) Imbalance of acuity of the two eyes is an important and relatively independent derived measure which might indicate functional development related to educational misuse of the vision mechanism;

(5) Phoria measures at far-point are the most valuable phoria measures, although near-point tests measure relatively separate, if less important entities;

(6) Vision functions may differ in importance for subjects who have uncorrected vision problems, for example, right eye acuity and vertical phoria assume greater importance in the vision of these subjects.

Vision and reading.--Reading skills and changes in reading skills were, for the total group of subjects, practically independent of vision functions. The presence of uncorrected vision problems in subjects apparently did increase the relationships between binocular acuity and reading comprehension changes. Yet, despite the fact that subjects with uncorrected vision problems tended to be initially higher in all reading skills, they made less gain in rate and more gain in story comprehension than did the group as a whole. These differences were not significant.

It was concluded that, at the level of reading performance of these subjects, vision functions were not a determining factor in the levels of reading skills attained, or in the change in the levels of reading skills as a result of a reading improvement course. These subjects had apparently been able to compensate for any uncorrected vision problems which were present. However, when faced with rapid increase in reading skills, subjects with uncorrected vision problems were required to expand greater effort controlling defective vision. This effort

prevented rapid rate increase and placed emphasis upon comprehension, a method believed to be the mode of compensation enabling these subjects to continue in higher education.

Vision and non-reading measures.--For the total group of subjects there were no meaningful relationships between vision functions and academic achievement or measured mental abilities. For subjects with uncorrected vision problems, however, there was a significant trend toward negative correlations between vision deviations and both academic achievement and measured mental abilities.

It was concluded that, for the general freshman population, vision was not related to academic achievement or measured mental abilities. However, uncorrected vision problems tended to interfere with subjects' academic achievement, and with their performance on measures of mental ability. This conclusion is drawn bearing in mind the many compensatory adjustments made by subjects under the stresses of cultural demands.

Reading and non-vision measures.--The correlations between both initial reading skills and reading skills change and (1) measured mental abilities, and (2) previous academic achievement were for all practical purposes nonexistent.

It was concluded that change in the levels of reading skills as a result of a reading improvement course is independent of verbal and quantitative mental abilities, and of previous academic achievement. It is believed that these college freshmen have verbal and quantitative abilities beyond minimum requirements for success, and changes in reading skills are dependent upon other variables, for example, motivation.

Reading skills changes were found to be negatively related to previous levels of reading skills. And each of three of the factors precipitated was specific to one reading skill and its concomitant change. It was concluded that reading skills changes are subject to the law of diminishing returns, that is, one might expect the initially lowest student to gain relatively more and the initially highest student to gain relatively less in reading skills. These facts must be applied with considerable caution to reading rate, since there are so many influences upon this skill.

General considerations.--One consistent trend pervaded the data in this study. Right eye acuity was seen to be an important differentiating measure between the total group and the vision problem subgroup. Right Acuity Deviation, Far was a specific factor precipitated in the factorization of scores of subjects with uncorrected vision problems, and in this factorization there was a significant ($p = .01$)[1] increase in the number of negative correlations between right eye acuity deviations and (1) initial reading skills, (2) reading skills changes, (3) academic achievement measures, and (4) mental abilities measures. For both groups, right acuity deviations were significantly correlated with acuity imbalance at near-point and far-point.

It was concluded that deviations in right eye acuity are highly important as an indication of adverse effects of vision problems upon academic-type activities. Such deviations apparently are not as easily controlled by the subject, and interfere with efficiency in continued near-point activities.

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[1] Chi square, corrected for continuity, equals 11.4.

The Hyperopia-Myopia variable appeared to be an important derived measure, but its exact role in the study was difficult to determine. There were minor negative correlations with initial reading rate and with all reading skills changes. Hyperopia-Myopia was the principal variable in the strongest factor elicited in both factorizations. Hyperopia-Myopia had significant positive correlations with the three measures of acuity deviation at far-point.

It was concluded that purified hyperopic and myopic tendencies[2] are important measures in vision. This type of derived measure utilizing various tests may be an answer to the reading clinician's problem of determining the effects of vision upon reading.

Clinical Considerations

Generally speaking, normal vision does not have a great effect upon the academic-type activities of college freshmen. However, a surprising number of these students do have uncorrected vision problems. These latter students have been able to compensate for vision problems throughout high school studies, but soon begin to feel the pressure of long-term, continuous demands which the college curriculum makes upon the vision mechanism. Symptoms range from tired eyes to excessive bodily tension preventing concentration.

Listed below are some considerations for the reading clinician which have emerged from the present study:

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[2]The deviation of this variable is explained on pages 82-83.

(1) Commercially available vision screening instruments, such as the Ortho-Rater, which offer a battery of vision tests, are necessary to adequately screen vision of students. Vision screening should be done with the primary purpose of understanding the potential of the student for reading improvement, and the secondary purpose of referral to a vision specialist for correction. Where clinical referrals are made, close communication is required to relate corrections to the reading needs of the student;

(2) Include monocular measures of acuity for each eye as well as binocular acuity tests; all tests should be given at far-point as well as at reading distance;

(3) Imbalance of acuity of the two eyes is an important consideration. There is an apparent relationship between right eye deviations at near-point and acuity imbalance. Where deviations are outside recommended norms for adults, this relationship increases, and tends to be negatively related to gain in reading rate. Right eye acuity deviations are seemingly more difficult to control, and therefore interfere more with academic-type activities;

(4) A derived measure of Hyperopia-Myopia is an important clinical consideration. The functionally derived measure used in the present study correlated highly with all far-point acuity measures. There tended to be minor negative relationships between Hyperopia-Myopia and change in levels of reading skills, especially Paragraph Comprehension Change. A thorough study of these relationships should be continued;

(5) Reading improvement at the college freshman level is apparently independent of verbal and quantitative ability, and of prior academic achievement. Students who have reached this academic level seem to be endowed beyond a minimum level required for progress;

(6) At this level, reading skills are relatively independent of each other, and the clinician might expect gain in one skill without great effect upon other skills;

(7) Gains in reading skills appear to be negatively related to initial levels of reading skills, therefore the clinician might expect diminishing returns from reading instruction. Students initially low in these skills would be expected to gain relatively more than students initially high in reading skills. Rate of reading must, of course, be considered in the light of the many affecting variables.

(8) The student with uncorrected vision problems is probably more rigid in his reading habits because of the necessity for a compensating control of vision. When placed in a reading improvement course, he probably will not gain as rapidly in rate, but he will reach a peak rate more quickly. His mode of compensation might well be to emphasize comprehension, particularly of the study-type requiring slower rate and additional effort.

One technique for combating this situation is emphasis upon skimming, or reading for ideas, so that the intense vision control is relaxed in favor of less critical images. A concomitant increase in rate is required to maintain the relaxed visual method. The technique obviously reduces comprehension initially, but can be utilized for many reading assignments. It will also lead the student toward flexibility in reading, a necessary part of college reading skills.

APPENDICES

APPENDIX A

GLOSSARY OF VISION TERMS

Accommodation: a change in the focus of the lens of the eye when changing the point of regard from far to near or vice versa; measured in units of power called the diopter.

Acuity: a measure of the smallest perceptible detail in black and white at a specified distance.

Acuity imbalance: a difference in the acuity of the two eyes; see Anisometropia.

Anisometropia: a difference in the refractive power of the two eyes; there are very few people without some degree; however, there is a native ability to tolerate and adapt to the difference if it is not large.

Anisekonia: a difference in the size and shape of the ocular images without a significant degree of anisometropia.

Astigmatism: a refractive error of the lens of the eye causing the light rays going into the eye to focus in different planes.

Binocular vision: vision involving images from both eyes; see Fusion.

Binocular coordination: movement of the two eyes together by means of the ocular muscles.

Color discrimination: a measure of the latest difference between colors, in different combinations, that can be perceived entirely apart from the need to recognize, name, or match specific colors.

Convergence: turning the eyes inward, crossing, in order to see a near object as a single image.

Depth perception: a measure of the minimum perceived difference in distance of two objects when all cues are eliminated except binocular parallax (the differential in the triangulation of the visual axes for the two different distances).

Diopter: a unit of measure of power of (1) accommodation of the lens of the eye, or (2) prescribed lenses.

Diplopia: doubling of vision.

Divergence: turning the eyes out in order to see a more distant object as a single image.

Ductions: muscular ability of the eyes to diverge and converge.

Esophoria: a tendency toward overconvergence.

Exophoria: a tendency toward underconvergence.

Far-point: at a distance from the eyes, with convergence relatively relaxed; for the Ortho-Rater, an optical distance of eight meters, approximately twenty-six feet.

Fusion: combining the images of both eyes into a single stereoscopic image.

Hyperopia: far-sighted; a refractive error of the lens of the eye causing far objects to be seen more clearly than near objects.

Interpupillary distance: the distance between the pupils of the eyes across the bridge of the nose.

Lateral imbalance: habitual faulty posturing of the eyes, causing underconvergence or overconvergence; imbalance of the ocular muscles in the lateral plane creating difficulty of fusion of two images.

Lateral phoria: the lateral angle between the axes of the two eyes; a measure of lateral imbalance.

Maddox Rod Test: a crude clinical measure of ocular imbalance.

Monocular vision: vision with one eye, as measured by a common test; or exclusive of frequent use of only one eye in normally binocular tasks; see Suppression.

Muscle imbalance: habitual faulty posturing of the ocular muscles in the vertical or lateral plane; see Phoria.

Myopia: near-sighted; a refractive error of the lens of the eye causing near objects to be seen more clearly than far objects.

Near-point: at approximate reading distance; for the Ortho-Rater, an optical distance of fourteen inches from the subject.

Overconvergence: a tendency to turn the eyes inward too far (crossing) when viewing an object binocularly; see Lateral imbalance.

Ortho-Rater: an instrument which presents a battery of standardized precision vision tests produced by the Bausch and Lomb Optical Company and standardized for industry by the Statistical Laboratory for Vision Tests at Purdue University.

Phoria: a measure indicating the lateral and vertical angles between the axes of the two eyes when they are not required to maintain coincidence on any single point of fixation, but with the eyes focused for a specific distance. Each phoria scale extends from one extreme through the normal to the other extreme.

Stereopsis: the ability to receive impressions of relief, solidity, and tri-dimensionality, achieved through depth perception.

Suppression: a functional disorder wherein the visual sensations from one eye are not utilized in image perception.

Underconvergence: a tendency to turn the eyes outward too far when viewing an object binocularly; see Lateral imbalance.

Vergence: lateral movement of the eyes inward or outward in the lateral plane in order to regard objects at varying distances.

Vertical imbalance: habitual faulty posturing of the eyes in the vertical plane, creating difficulty of fusion of the two images.

Vertical phoria: the vertical angle between the axes of the two eyes; a measure of vertical imbalance.

APPENDIX B_1

VISUAL ACUITY EQUIVALENTS OF ORTHO-RATER ACUITY LEVELS

Test Item Number	Visual Angle	Visual Acuity Notation	
		Snellen	A.M.A.
1	10.0'	20/200	20%
2	5.0'	20/100	49%
3	3.33'	20/67	67.5%
4	2.5'	20/50	76.5%
5	2.0'	20/40	84.5%
6	1.67'	20/33	88.5%
7	1.43'	20/29	92.5%
8	1.25'	20/25	95.5%
9	1.11'	20/22	98%
10	1.0'	20/20	100%
11	.91'	20/18	101.5%
12	.83'	20/17	103%
13	.77'	20/15	104%
14	.71'	20/14	105.5%
15	.67'	20/13	106.5%

APPENDIX B_2

INDIVIDUAL VISION PROFILE

Name_____ Date____

Group___

Use of glasses: none ____ reading only ____ distance only _____

full-time ____ number of years ____

Contact lenses: yes - no (check one)

Directions: With glasses, use X; without glasses, use 0. Raw score on top of line; deviation score below line.

Far-Point

Vertical Phoria	X	1	2	3	4	5	6	7	8	9					
		4	3	2	1	0	1	2	3	4					
Lateral Phoria	X	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Acuity, Both	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Acuity, Right	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Acuity, Left	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Stereopsis	0	1	2	3	4	5	6	7	8	9						
	0	1	2	3	4	5	6	7	8	9						
Color	0	1	2	3	4											
	0	1	2	3	4											

Near-Point

Vertical Phoria	X	1	2	3	4	5	6	7	8	9					
		4	3	2	1	0	1	2	3	4					
Lateral Phoria	X	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Acuity, Both	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Acuity, Right	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Acuity, Left	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		7	6	5	4	3	2	1	0	1	2	3	4	5	6	7

Comments:

APPENDIX B_3

NAME ______________________ READING SECTION 1-1 1-2 2-1 2-2 3-1 3-2

Last First Circle One

FILMSTRIP ANSWER SHEET

Film No.	Rate	Comp.	1	2	3	4	5	6	7	8	9	10	COMMENTS:

APPENDIX C_1

INTERCORRELATION MATRIX, GROUP T (N=163)

#	Variables Name	1	2	3	4	5	6	7	8	9	10
1	Reading Rate	1.00									
2	Reading Story Comprehension	-.05	1.00								
3	Reading Paragraph Comprehension	.07	.39	1.00							
4	Vertical Phoria Deviation, Far	-.07	-.04	-.09	1.00						
5	Vertical Phoria Deviation, Near	.02	-.03	-.04	.23	1.00					
6	Lateral Phoria Deviation, Far	.08	-.06	.08	.27	.10	1.00				
7	Lateral Phoria Deviation, Near	.01	.06	.14	.07	-.07	.12	1.00			
8	Acuity Deviation Both, Far	.01	.12	.07	-.10	.05	-.01	-.08	1.00		
9	Acuity Deviation Both, Near	.05	.14	.07	-.06	.06	-.05	.00	.23	1.00	
10	Acuity Deviation Right, Far	-.04	.04	.08	-.06	.11	.02	-.03	.40	.13	1.00
11	Acuity Deviation Right, Near	-.05	.08	.06	.14	.16	-.04	-.04	.04	.14	.40
12	Acuity Deviation Left, Far	.13	.11	.17	.00	-.04	.12	.05	.40	.13	.25
13	Acuity Deviation Left, Near	-.05	.07	.10	-.08	-.03	.02	.00	.24	.41	.14
14	Acuity Imbalance, Far	.06	.04	.10	.14	.06	.09	.01	.01	-.11	.41
15	Acuity Imbalance, Near	.02	-.01	-.01	.21	.15	.01	-.02	-.01	-.01	.24
16	Class Rank	-.01	.03	.11	-.04	-.04	-.03	.11	-.06	.09	-.07
17	SAT Verbal	.05	.12	.11	.04	.03	-.04	.08	.02	.04	.06
18	SAT Mathematical	.02	.05	-.06	-.01	.04	-.11	-.01	.04	.01	.00
19	PGA	.00	.17	.23	-.03	-.08	-.05	.06	.01	.19	-.07
20	Hyperopia-Myopia	-.08	.10	.09	.01	-.02	.04	.04	.38	.15	.40
21	Rate Change	-.35	.04	-.01	-.07	.05	.00	.00	-.06	.06	-.10
22	Story Comprehension Change	-.05	-.63	-.18	.19	-.02	.15	.08	-.14	-.11	-.06
23	Paragraph Comprehension Change	.01	-.07	-.61	.12	.09	-.06	.05	-.02	.02	-.01

APPENDIX C_1 (continued)

11	12	13	14	15	16	17	18	19	20	21	22	23
1.00												
.07	1.00											
.24	.28	1.00										
.32	.46	.14	1.00									
.50	.22	.21	.53	1.00								
-.18	.01	-.08	-.01	-.04	1.00							
.13	.02	.07	.02	.09	.11	1.00						
-.04	-.02	-.08	-.11	-.05	.13	.48	1.00					
-.08	.06	.01	-.08	-.08	.73	.34	.40	1.00				
.07	.44	.14	.10	.04	-.01	.05	.01	.01	1.00			
-.09	-.14	.02	-.09	-.07	.13	.02	-.01	.09	-.12	1.00		
-.05	-.04	-.06	.04	.05	.03	.05	.03	-.03	-.01	-.10	1.00	
.01	-.03	-.06	.04	.05	.09	.04	.01	.07	-.02	.02	.14	1.00

APPENDIX C_2

INTERCORRELATION MATRIX, SUB-GROUP VP (N=51)

#	Variables Name	1	2	3	4	5	6	7	8	9	10
1	Reading Rate	1.00									
2	Reading Story Comprehension	.26	1.00								
3	Reading Paragraph Comprehension	.33	.48	1.00							
4	Vertical Phoria Deviation, Far	.04	.14	-.05	1.00						
5	Vertical Phoria Deviation, Near	-.07	.04	-.11	.38	1.00					
6	Lateral Phoria Deviation, Far	.10	.09	.19	.16	.01	1.00				
7	Lateral Phoria Deviation, Near	-.06	.07	.04	-.11	-.29	.04	1.00			
8	Acuity Deviation Both, Far	-.02	.19	.19	-.31	.01	.04	-.21	1.00		
9	Acuity Deviation Both, Near	.17	.05	.15	-.17	.12	-.07	-.05	.15	1.00	
10	Acuity Deviation Right, Far	-.16	.05	.00	-.08	.03	.03	-.34	.54	.15	1.00
11	Acuity Deviation Right, Near	-.12	.08	-.04	.20	.20	-.11	-.30	-.02	.04	.50
12	Acuity Deviation Left, Far	.15	.14	.17	-.05	-.16	.12	-.15	.43	.06	.26
13	Acuity Deviation Left, Near	-.07	-.09	.13	-.11	.04	.11	-.04	.19	.49	.16
14	Acuity Imbalance, Far	-.01	.09	.03	.30	.01	.04	-.18	-.05	-.10	.33
15	Acuity Imbalance, Near	-.11	-.06	-.03	.25	.13	-.13	-.24	-.16	-.11	.24
16	Class Rank	.10	-.04	.07	-.02	-.03	-.04	.11	-.14	-.07	-.22
17	SAT Verbal	.06	.01	.24	.00	-.18	-.01	-.19	-.25	.09	-.19
18	SAT Mathematical	-.06	.09	-.06	.09	.01	-.08	-.03	.09	-.05	-.08
19	PGA	.08	.05	.14	.04	-.12	-.03	.06	-.11	.05	-.29
20	Hyperopia-Myopia	-.15	.09	.16	-.17	-.14	-.04	-.12	.56	.11	.35
21	Rate Change	-.29	.04	-.13	-.09	.08	.05	.21	-.07	.15	-.10
22	Story Comprehension Change	-.16	-.72	-.17	.07	-.10	.07	.09	-.40	-.21	-.16
23	Paragraph Comprehension Change	-.05	-.12	-.70	.27	.11	-.06	.05	-.32	-.10	-.08

APPENDIX C_2 (continued)

11	12	13	14	15	16	17	18	19	20	21	22	23
1.00												
-.07	1.00											
.12	.39	1.00										
.44	.60	.30	1.00									
.64	.19	.23	.65	1.00								
-.30	-.04	-.18	.04	-.03	1.00							
.04	.00	.13	.02	.03	.20	1.00						
-.12	.04	-.17	-.17	-.16	.28	.12	1.00					
-.25	-.02	-.04	-.12	-.14	.72	.53	.65	1.00				
-.11	.49	.06	.09	-.09	-.13	-.15	.04	-.17	1.00			
-.12	-.26	.05	-.18	-.11	.05	.13	-.18	-.02	-.10	1.00		
-.10	-.09	-.02	.05	.14	.11	.07	.05	.09	-.06	-.14	1.00	
.01	-.03	-.13	.24	.06	.16	.05	.01	.11	-.28	.11	.09	1.00

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BIOGRAPHICAL SKETCH

David Eugene Edgar was born August 3, 1925, at Fordyce, Arkansas. In June, 1943, he was graduated from Fordyce High School. From 1943 until 1947 he served in the United States Navy as a fighter pilot. Following his release to inactive duty, he entered Southern Methodist University, where he majored in Clinical Psychology. In June, 1951, he received the degree of Bachelor of Arts, and in June, 1953, he received the degree of Master of Arts from Southern Methodist University. He continued his graduate studies at the University of Colorado and worked for two years in Denver, Colorado, while obtaining his teaching certificate. During the school year 1955-56 he was Counselor at the Emily Griffith Opportunity School for the Denver Public Schools. He was School Psychologist, then Coordinator, Exceptional Child Program, for the Volusia County, Florida Board of Public Instruction. From February, 1961, until the present time he has pursued his work toward the degree of Doctor of Education. During this time he worked as a graduate assistant in the Reading Laboratory and Clinic, and taught at Stetson University.

David Eugene Edgar is married to the former Margaret Isabel Bingham and is the father of three children. He is a member of Florida Education Association, Florida Psychological Association, Florida Association of School Psychologists, and Delta Kappa Epsilon.

This dissertation was prepared under the direction of the chairman of the candidate's supervisory committee and has been approved by all members of that committee. It was submitted to the Dean of the College of Education and to the Graduate Council, and was approved as partial fulfillment of the requirements for the degree of Doctor of Education.

August 14, 1965

Kimball Wiles
Dean, College of Education

Dean, Graduate School

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